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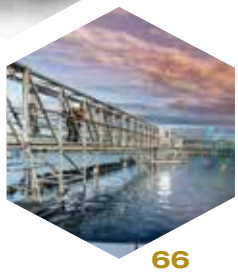

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# Editor's Page

## The next generation of leaders

Much is being said and written about the changes taking place in today's workforce. The conversation is often about the difficulty in finding and retaining talent, concerns about losing legacy knowledge as people retire, and the differences in work culture and expectations of the growing millennial workforce. While people-related issues are often cited as the biggest challenges for today's CEOs, the most important concern, according to a recent survey, is the development of our next generation of leaders.

The survey report*, Global Leadership Forecast 2018: 25 Research Insights to Fuel Your People Strategy (GLF), is a collaborative effort by Development Dimensions International (DDI), The Conference Board and Ernst & Young (EY). It outlines trends and makes recommendations based on data from over 25,800 leaders and 2,500 human resource professionals at 2,488 organizations across 26 industries.

### Team leadership

Leadership involves the ability to influence and motivate people, and to empower them to do their best. Good leaders know that they don't have all the answers — they seek out the input of those that they lead as well as from others, and know that teamwork is important. Teamwork is highlighted as a megatrend in the GLF report, but not just in individual work teams, but also for leaders themselves. The report says that the survey data clearly show that leaders will increasingly be expected to work in shared leadership environments, due to increasing complexities in our work environment, which make it more important to work in multidisciplinary groups.

In my own experience, multidisciplinary or cross-functional teams are fairly common in the chemical process industries. Leading workers who do not report to you organizationally, and sharing leadership require a willingness on the part of leaders to truly collaborate. As the GLF report states, shared leadership also requires a company culture that enables such a leadership style.

### Digitalization and diversity

Not surprisingly, rapid changes in digitalization are affecting the skill sets needed by leaders, which include technical and analytical skills, as well as interpersonal skills. Leaders need to overcome old mindsets and adapt to changes. They also need to be able to lead virtual or remote teams, which are becoming more common, in part due to digitalization.

While much attention has been given to millennials, the report warns not to underestimate Generation X (those born between 1961 and 1981), who are actually the next generation of leaders, and in fact already hold 51% of leadership roles globally. Generation X are the early adopters of digital technologies and rated themselves just as confident in their digital skills as millennials in the survey.

The GLF report also indicates that companies with a stronger balance of gender diversity in leadership roles show some key advantages, including having a culture of inclusivity with multiple perspectives and more collaboration across organizational boundaries.

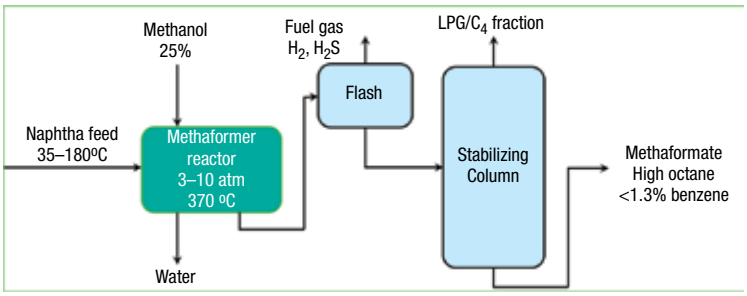
While fundamental leadership skills will remain essential, overall strategies for leadership are evolving with our increasingly digitized world. ■

*Dorothy Lozowski, Editorial Director*

*Global Leadership Forecast 2018: 25 Research Insights to Fuel Your People Strategy, by DDI, the Conference Board and EY, February 7, 2018, https://www.ddiworld.com/glf2018

## Methaforming process offers lower-cost naphtha upgrading for refiners

Petroleum refiners looking to upgrade low-octane naphtha have an additional option using a process that increases the higher-octane iso-paraffins and aromatic compounds at lower costs than currently available alternatives.




*New Gas Technologies Synthesis*

Most refiners currently upgrade naphtha by hydrotreating followed by isomerization and continuous catalytic regeneration (CCR) reforming. A new process, known as Methaforming and licensed from New Gas Technologies Synthesis (NGTS; Houston; www.ngts.us), performs the upgrading in a single unit, without the need for hydrotreating. Replacing several processes with a single unit results in a capital cost one-third that of the alternative technologies, says Stephen Sims, NGTS president.

Methaforming uses a proprietary zeolite catalyst that was originally developed by Russian researchers to convert methane to gasoline. When that line of research did not bear fruit, the catalyst was tested with other feeds, such as naphtha and raffinate from aromatics extraction.

When used in a fixed-bed, adiabatic reactor with methanol injection, the catalyst dehydrogenates methanol to release methyl radicals, which initiate a series of reactions that convert linear paraffins in the low-octane feeds into dual branched iso-paraffins, and naphthenes into aromatic compounds. The result is an increased research octane number (RON) in the product. The catalyst utilizes rare-earth elements instead of precious metals, such as platinum and rhenium.

The first Methaformer installation is a "pilot demonstration" unit at a Russian facility that produces 150 barrels per day (bbl/d) of gasoline from naphtha and methanol. Another, smaller pilot plant, designed to generate additional test data for a larger unit, is being completed this month in South Korea for use at a Moscow research facility.

Methaforming is versatile — the process can be built from scratch or can be retrofitted into an idle hydrotreater or reformer to further save costs. Also, the Methaforming process can use ethanol along with, or instead of, methanol, or ethylene from the fluid cazalytic cracking (FCC) unit. The Methaformer reduces sulfur by 90% and can handle up to 1,000 parts per million (ppm) sulfur in the feed, Sims says.

## A new hydrotreating catalyst

Hydrotreating is an important petroleum refining process in which sulfur and other contaminants are removed in the manufacture of transportation fuels. At the recent annual meeting of the American Fuel and Petrochemical Manufacturers (AFPM), Honeywell UOP (Des Plaines, Ill.; www.uop.com) introduced a new hydrotreating catalyst designed to remove sulfur and nitrogen from lower-value diesel-fuel blending components. Known as ULTIMet, the catalyst can process feed material with higher levels of sulfur than previous catalysts in UOP's hydrotreating portfolio.

The concept behind the new product is to increase catalytic activity by concentrating the number of active sites available for chemical reactions. "There are more active sites per cubic meter of reactor volume than previous catalysts, allowing [ULTIMet] to handle more challenging, lower-priced feedstocks than conventional hydrotreating catalysts," explains Brenna Huovie, senior business leader for hydrotreating catalysts, adsorbents & specialties at Honeywell UOP.

The ULTIMet catalyst works as a drop-in replacement for existing hydrotreating catalysts, and can be loaded into reactors along with conventional catalysts to improve performance and increase plant capacity without capital expense, UOP says.

UOP's Huovie also notes that the new catalyst is manufactured with a higher-strength material that prevents particle breakage and increases the attrition resistance of the catalyst material. This can help extend the operating cycle by as much as 50–75%, UOP says.

The ULTIMet catalyst can help to bring lower-value hydrocarbons into compliance with the Euro V fuel standards, which specify sulfur content of less than 10 ppm.

Edited by:
**Gerald Ondrey**

### PET RECYCLING

Last month, Unilever N.V. (Rotterdam, the Netherlands.; www.unilever.com) announced a partnership with start-up company Ioniqa Technologies B.V. (Eindhoven, the Netherlands; www.ioniqa.com) and the polyethylene terephthalate (PET) resin producer Indorama Ventures plc (Bangkok, Thailand; www.indoramaventures.com) to pioneer a new technology that converts PET waste back into virgin-grade material for use in food packaging.

Ioniqa, a spin-off from the Eindhoven University of Technology (the Netherlands), has developed a proprietary technology that is able to convert any PET waste — including colored packs — back into transparent virgin grade material (*Chem. Eng.*, January 2016, p. 7). The technology has successfully passed its pilot stage and is now moving toward testing at an industrial scale.

PET is widely used to produce plastic packaging, yet worldwide only around 20% of this material makes its way to recycling plants, with the rest either incinerated, disposed of in landfills or leaked into the natural environment. The partners aim to tackle this challenge. If proven successful at industrial scale, in the future, it will be possible to convert all PET back into food-grade packaging.

### Zn-BASED GLASS

An international team of researchers has developed a new type of glass that resists crystallization better than existing glass, thereby making it far more pliable. Silica glass has a tetrahedral structure, with silicon in the center and four oxygen atoms at the corners. The metal-organic glass the researchers developed, termed ZIF-62, substi-

(Continues on p. 8)

tutes zinc for silicon, and uses two organic compounds at the corners — imidazolate and benzimidazolate. These organic molecules randomly take the place of the oxygen atoms at the tetrahedron corners.

The researchers noted that the more benzimidazole incorporated into the metal-organic framework, the better the glass-forming ability. The more viscous liquids with the bulkiest ligands tend to resist crystallization the best.

Zn-based organic glass is more difficult to produce than silica glass because the organic compounds first need to be synthesized, mixed with hydrous zinc nitrate and a solvent. The mixture then melts at about 420°C. Temperature is important because the mixture must melt completely, but remain below 520°C, at which point the molten glass will vaporize. The researchers are investigating other metallic-organic combinations, and now plan to look at a cobalt-based glass. They also need to find out how to scale up their process.

The team includes people from Wuhan University of Technology (China), the University of Cambridge (U.K.; www.cam.ac.uk), the National Institute of Chemistry (Ljubljana, Slovenia), CSIRO (Melbourne, Australia), Qilu University of Technology

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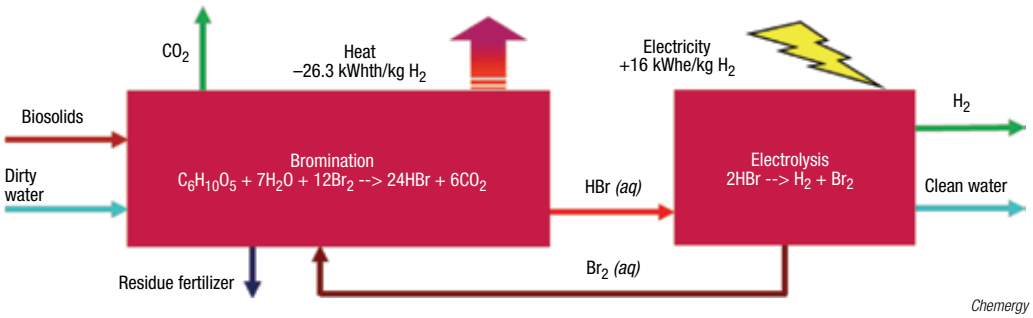
## Using $Br_2$ to make renewable $H_2$ from biowaste




Chemergy

A process that produces renewable hydrogen from organic biowaste and reduces the economic and environmental burden of wastewater treatment is being developed by Chemergy, Inc. (Miami Fla.; www.chemergy.com). Introduced at last month's AIChE Spring Meeting (April 22–26; Orlando, Fla.), Chemergy's HyBrTec technology offers an alternative method for processing sewage, manure, wood and agricultural residues, paper, plastics and municipal solid waste. Depending on the feedstock, the process can recover up to 420 lb of $H_2$ per dry ton of biowaste, says CEO Robin Parker.

HyBrTec utilizes two established steps (diagram) that are scalable to tons per minute with commercially available equipment, says Parker. First, cellulosic biowaste and wastewater are oxidized with bromine to produce HBr, $CO_2$ and heat. The HBr reacts with unreacted water, forming concentrated hydrobromic acid ($HBr_{aq}$). The $HBr_{aq}$ is then electrolyzed into $H_2$ and recyclable $Br_2$ reagent.

The heat released in the bromination step is recovered and used to concentrate the water content of the feedstock to 50 vol.%. Electro-osmotic water transfer from the $Br_2$ anode to the $H_2$ cathode produces 4–6 gal of potable water per kilogram of $H_2$ and increases the acid concentration at the anode, which lowers cell voltage below 1 V, which is more than half the 2 V required for water electrolysis. In addition, the electrolyzer is reversible (2HBr $\leftrightarrow$ $H_2$ + $Br_2$), affording an efficient energy-storage capability, points out Parker.

The HyBrTec process has been demonstrated at bench-scale, with funding from the U.S. Dept. of Energy and the Florida Hydrogen Initiative. Since 2013, the California Energy Commission has funded Chemergy in a cost-sharing program to design a pilot demonstration and to perform an economic analysis of a commercial system. The pilot plant will be housed in a 40-ft ISO container, and be capable of processing 3–5 wet-tons of biowaste per 8-h operating day.

## Removing $H_2S$ from crude petroleum on-site

Hydrogen sulfide occurs naturally in petroleum reservoirs, but must be removed from crude oil prior to transportation from drilling sites to storage tanks at petroleum refineries. $H_2S$ is corrosive to storage tanks, pipelines and railcars, and without proper treatment, can generate flammable and dangerous vapors.

RevEnergy (Aberdeen, S.D.; www.revenergy.com) recently introduced a novel modular technology for removing $H_2S$ from crude oil at the petroleum source to levels lower than 4 ppm by weight (ppmw), well below the industry-accepted standard for crude oil transport (10 ppmw $H_2S$). The technology results from a collaboration with Aecom (Los Angeles, Calif.; www.aecom.com).

The technology, known as Rev$H_2S$, is a patent-pending, closed-loop unit that strips $H_2S$ from crude petroleum using an inert gas. The identity of the inert gas is a trade secret, but Jason Groves, RevEnergy CEO, says it does not react with any components of the crude petroleum or change any properties of the oil, beyond removing $H_2S$.

After introducing the inert gas into the crude petroleum, the $H_2S$ is captured along with the inert gas and treated to separate the $H_2S$. The contaminant gas is then converted to a much safer waste product for disposal.

"The Rev$H_2S$ system is contained in a mobile unit that is placed near the crude petroleum source for treatment at the site," says Groves. "It is designed to treat crude petroleum with $H_2S$ contents up to 300 ppmw in a single pass, but can remove higher levels by treating with multiple passes." Further, he notes that it does not result in any volume loss, leave any chemicals behind, or require a Title V permit.

Designed to remove $H_2S$ and some light mercaptans, Rev$H_2S$ does not affect other organic sulfur compounds in the crude petroleum.

RevEnergy launched the technology as a commercial service last month, and is working to secure an initial installation agreement.

(For more news about petroleum refining, see the Newsfront, "Refinery Responsiveness Front and Center," on pp. 14–18).

## Robotic device removes catalyst from reactors remotely

A remote-operated, screw-propelled (amphirol) machine equipped with a vacuum hose can remove solid catalyst material from reactors robotically, allowing plants to avoid subjecting personnel to enclosed work environments and inert atmospheres. Currently, catalyst changeout requires personnel to work inside process vessels with breathing apparatus to remove the materials.

Developed by WorleyParsons (Brisbane, Australia; www.worleyparsons.com), the robotic device is equipped with a vacuum hose to suck granular material out of the vessel, and dual rotating screws that allow it to move across the surface of solid material (photo). The robot, dubbed Carol (catalyst amphirol), also has an onboard camera, which allows an engineer to operate it safely from outside the vessel.

The robot is lowered into the process vessel by a crane-and-winch system, and then "floats" on top of the solid catalyst as it is maneuvered around the vessel to remove the solid material, explains lead developer and WorleyParsons engineer Chris Jansen. The hydraulically powered screw-drive design is key to the robot's operation, Jansen says, because it allows versatile and nimble movement through the granular material in all directions without getting stuck.

*WorleyParsons*

In manual versus robot trials, the Carol system achieved catalyst removal rates that exceeded that of humans over the unloading period, WorleyParsons says.

After a successful demonstration of the remote robotics technology last year, WorleyParsons is now beginning a "beta testing" phase by conducting two in-plant catalyst-changeout field trials. The first began in late April at a liquefied natural gas (LNG) plant in Australia, and the second is scheduled to begin in late May at a U.S. petroleum refinery.

(Jinan, China), Pennsylvania State University (University Park, Pennsylvania), Aberystwyth University (U.K.) and Aalborg University (Denmark).

### DEWAXING CATALYST

Clariant's Catalyst business (Munich, Germany; www.clariant.com) has launched a new diesel dewaxing catalyst, HYDEX E, an extension of the company's HYDEX series, which is designed for selective hydrocracking of long-chain normal paraffins to improve the cold-flow properties of middle distillates. Catalytic dewaxing is essential for regulating fuel fluidity characteristics of diesel fuel to ensure reliable applicability and performance. This is particularly true for cold weather conditions.

Until now, the series included HYDEX G for dewaxing diesel and kerosene, HYDEX L for viscosity adjustment of heavy hydrocarbons, and special catalyst solutions tailored to users' needs. The range was expanded to create a new catalyst that allows operation under full sour-service conditions. HYDEX E achieves this thanks to its robust zeolite content, which is combined with non-precious metal composition to ensure stable hydrogen transfer. On-site testing of HYDEX E in an ultra-low sulfur diesel (ULSD) hydrotreater pilot plant resulted in approximately 4 wt.% more on-road diesel product compared to previous HYDEX generations.

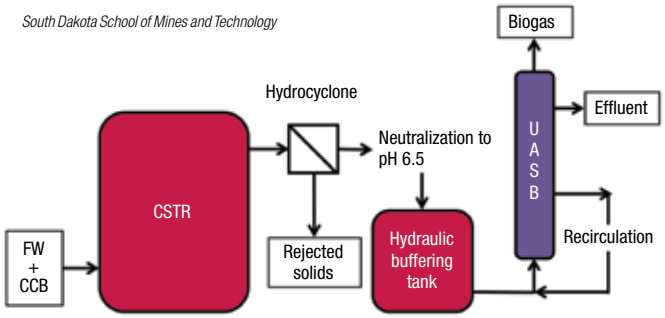
### CORROSION PROTECTION

To prevent corrosive substances from penetrating into steel structures, a common method is to create an anti-corrosion coating by painting layers of zinc-phosphate particles. Now, researchers at INM – Leibniz Institute for New Materials GmbH (Germany; www.inm-gmbh.de) have developed flake-shaped metal-phosphate particles that show improved passivation ability and an improved diffusion barrier against corrosive substances.

Because of their anisotropy, the flake-shaped particles show a better solubility compared to spherical particles

(Continues on p. 11)

## Truck-mounted process turns waste to methane




A group of researchers from South Dakota School of Mines and Technology (SDSM&T; Rapid City; www.sdsmt.edu) has developed a modular technology known as the Gas Cube, which can convert a wide variety of liquid and solid waste into methane. Having a viable, flexible solution for waste management in remote locations is paramount for saving costs and ensuring sustainability. The portable technology's first application will be treating kitchen waste from a U.S. Air Force base in a remote location. Along with food waste, SDSM&T says that the Gas Cube is also suitable for handling cardboard, agricultural residues or even wastewater.

In the process (diagram) the solid waste is first fed to a shredder. Then, in a continuously stirred tank reactor (CSTR), hydrolytic microorganisms convert the waste materials into sugars, and fermenting microbes further break down the sugars into fatty acids. Remaining solids are filtered out and given more time to react. The fatty acids are then fed to a vertical chamber for a process dubbed upflow anaerobic sludge blanket (UASB). Here, methanogenic microbes transform them into $CH_4$, which can be used at the site to run generators or other equipment. The ability to handle a mixture of food and cardboard waste, along with the adoption of a two-stage anaerobic digestion process to a portable, skid-mounted unit, make the Gas Cube especially unique, says Patrick Gilcrease, professor of chemical and biological engineering at SDSM&T.

The Gas Cube has been demonstrated using 2-L reactors, and a field prototype unit is currently undergoing tests. "Rather than further scaleup, the plan is to send multiple truck-mounted units to handle more waste at a given site," explains Gilcrease. "If prototype tests are successful, the next steps will be testing alternative wastes that could benefit from small-scale onsite treatment. Microbreweries are one possibility," he adds. Another task will be to reduce the unit's weight for ease of transportation. Currently, the prototype uses carbon-steel tanks, but the use of plastic tanks would greatly decrease weight.

## A more sustainable colorant technique for polyester fibers

The global textile industry generates a great deal of waste, and many efforts are taking place to make textile processing more sustainable. PolyOne Corp. (Cleveland, Ohio; www.polyone.com) has introduced a new fiber-colorant technology for polyester that incorporates proprietary high-pressure metering equipment with the company's ColorMatrix liquid concentrates. The technology enables the color-injection step to take place further downstream than in conventional colorant processes.

In the new ColorMatrix process, liquid color is injected into the polyester melt-flow between the end of the extruder and the spin head. This later-stage injection minimizes color contamination and reduces the time required for cleaning and color changeout. Furthermore, several injection points can be added to run multiple colors or additives simultaneously on a single extruder line. This flexibility is especially beneficial to small-batch production, as manufacturers can use the same process to make a wide range of volumes and the process can be rapidly scaled onsite. Also, the new technology enables facilities that use reactor spinning lines to produce standard white polyester fibers to produce colored products inline, eliminating the need for a secondary aqueous dyeing process.

Traditional aqueous dyeing processes can use up to 10 L of water to color a single kilogram of fiber, but this new spin-coloring technology reportedly requires no water and consumes less energy and fewer chemicals. Additionally, it eliminates the secondary treatment operations typically required to discharge wastewater safely into the environment. The technology's precise mixing elements are crucial to harnessing the full benefits of flexibility and efficiency, says PolyOne.

So far, the technology's deployment has been focused on specific projects, but plans are in place to scale up the process for users' core product ranges. According to PolyOne, while the technology is currently targeted to polyester fibers, plans are underway to begin exploring its application for other polymer fibers, including nylon and polypropylene.

## Protein engineering yields animal-free leather

A new fermentation-based technology aims to create leather materials from yeast rather than animal skin. Developed by Modern Meadow (Nutley, N.J.; www.modernmeadow.com), the process feeds sugar feedstock to yeast cells that have been engineered to create collagen. Some additional enzymes are required during fermentation to facilitate the yeast's production of collagen. The collagen is then purified and assembled to create the bioleather material known as Zoa.

Not only is the production time for Zoa significantly lower than for animal-based leather, the material is also very customizable for shape, size, texture and other properties, explains Dave Williamson, Modern Meadow's chief technology officer. He likens the process to the activities of a fibroblast cell — assembling collagen proteins into collagen fibers in human and animal tissue — taking place in large-scale process vessels. Zoa is biologically the same as traditional leather, but it also enables functionality that is not possible with traditional leather, including the ability to be poured or sprayed in a liquid form, and the potential for integration with other fibrous media to make composite materials. "We can change or introduce a functional group on the protein to alter material properties, such as softness, colorfastness, or even material strength," says Williamson. Starting with the production of collagen proteins makes the process not only highly tunable in terms of end-product properties, but also scalable and logistically efficient. "We can purify and ship the protein anywhere in the world for conversion to the final material. We are able to have complete control over the structure and properties of the protein," he adds.

Modern Meadow recently announced a joint-development agreement with Evonik Industries AG (Essen, Germany; www.evonik.com) to scale up the technology to produce Zoa at commercial level. The group expects to launch its first commercial product in the next 1–2 years. The partners will also move forward with the expansion of a pilot facility later this year. ■

with similar composition. "Now, more phosphate ions are set free from the coating on-demand and re-passivation of bare metal surface (as a consequence of a mechanical damage, for example) is more effective," says Carsten Becker-Willinger, head of the program division Nanomers. "Furthermore, the flake-type particles arrange in the coating in a roof-tile manner. This means that the pathway for the penetration of the corrosive gas molecules through the protective coating is prolonged because they have to find their way around the flakes," explains Becker-Willinger.

Standardized accelerated-corrosion tests on steel plates coated with epoxy resins containing metal phosphate particles show that coatings containing phosphate flakes behave about ten times better than coatings containing spherical phosphate particles, says INM. Besides zinc phosphate, newly developed manganese-phosphate flakes are also available. The technology was unveiled at the Hannover Messe (April 23–27; Hannover, Germany). ❑

## LINEUP



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## Plant Watch

### Saudi Aramco and RRPCL to proceed with integrated megaproject in India

April 12, 2018 — Saudi Aramco (Dhahran, Saudi Arabia; www.saudiaramco.com) signed a memorandum of understanding (MOU) with Ratnagiri Refinery and Petrochemicals Ltd. (RRPCL), a consortium of Indian oil companies, to jointly develop and build an integrated petroleum refinery and petrochemicals complex in Ratnagiri, India. The refinery will provide feedstock for the petrochemical complex, which will have a production capacity of 18 million metric tons per year (m.t./yr).

### Yara and BASF open world-scale ammonia plant in Freeport, Texas

April 12, 2018 — Yara International ASA (Oslo, Norway; www.yara.com) and BASF SE (Ludwigshafen, Germany; www.basf.com) opened a new ammonia plant in Freeport, Tex. The $600-million facility has capacity to produce 750,000 m.t./yr of ammonia. BASF will use its share of the ammonia offtake to produce polyamide 6.

### BASF starts up new polyarylsulfone production line in South Korea

April 12, 2018 — BASF has started up a new production line for the high-temperature-resistant thermoplastic polyarylsulfone at its site in Yeosu, South Korea. With the new line, BASF's global capacity for this product will increase by 6,000 m.t./yr to 24,000 m.t./yr.

### Evonik to expand production capacity for methacrylate crosslinkers in Alabama

April 10, 2018 — Evonik Industries AG (Essen, Germany; www.evonik.com) is expanding its production capacities for methacrylate crosslinkers at its site in Mobile, Alabama. Startup of the expanded facility is scheduled for the third quarter of 2018. The crosslinkers are used in paints, coatings, composites and plastics.

### Cepsa to upgrade linear alkylbenzene production at Puente Mayorga site

April 9, 2018 — Compañía Española de Petróleos S.A.U. (Cepsa; Madrid, Spain; www.cepsa.com) will implement a new upgrade project to expand the production of linear alkylbenzene (LAB) at its Puente Mayorga site in San Roque, Spain. The revamp will increase LAB production capacity at the plant from 200,000 m.t./yr to 250,000 m.t./yr.

### Mitsubishi Chemical and Sabic start up joint production site in Saudi Arabia

April 4, 2018 — The Saudi Methacrylates Co. (Samac), a 50-50 joint venture (JV) of Mitsubishi Chemical Corp. (MCC; Tokyo; www.m-chemical.co.jp) and Saudi Basic Industries Corp. (Sabic; Riyadh; www.sabic.com) has successfully completed performance tests and commenced commercial operation at its two new units producing methyl methacrylate (MMA) monomer and polymethyl methacrylate (PMMA) in Saudi Arabia. The JV will manufacture 250,000 m.t./yr of MMA monomer and 40,000 m.t./yr of PMMA.

### Mitsui to build production plant for thermoplastic olefin elastomers in Ohio

March 26, 2018 — Mitsui Chemicals, Inc. (Tokyo, Japan; www.mitsuichem.com) plans to set up a new production facility for the thermoplastic olefin elastomer Milastomer at the Ohio-based plant of its U.S. subsidiary Advanced Composites, Inc. The new line will be designed to produce 6,000 m.t./yr of Milastomer. Construction is slated to begin in January 2019, with commercial startup expected in October 2019.

### Showa Denko expands production capacity of hydrogen bromide

March 26, 2018 — Showa Denko K.K. (SDK; Tokyo, Japan; www.sdk.co.jp) has expanded its capacity to produce high-purity hydrogen bromide (HBr), which is used in the manufacture of semiconductors. The expansion increased SDK's HBr production capacity from 600 m.t./yr to 900 m.t./yr.

## Mergers & Acquisitions

### WorleyParsons completes acquisition of M+W Group assets in Germany

April 10, 2018 — WorleyParsons Ltd. (North Sydney, Australia; www.worleyparsons.com) completed the strategic acquisition of M+W Group's (Stuttgart, Germany; www.mwgroup.net) assets in Ludwigshafen and Schwarzheide, Germany. The acquired business provides engineering services to chemical companies, including feasibility studies, concept development, engineering and project and construction management.

### Alfa Laval to sell its tubular heat-exchanger business

April 5, 2018 — Alfa Laval AB (Lund, Sweden; www.alfalaval.com) has signed an agreement to sell its commercial tubular heat-exchanger business to the Bitzer Group. The commercial tubular heat-exchanger business has its base in Alonte, Italy, and reported revenues of about SEK 120 million (around $14.3 million) in 2017.

### TechnipFMC acquires epichlorohydrin process technology from Solvay

March 30, 2018 — TechnipFMC (Houston; www.technipfmc.com) has completed the acquisition of Epicerol technology from

Solvay S.A. (Brussels, Belgium; www.solvay.com). The technology converts glycerol to high-purity epichlorohydrin (ECH) for use in coatings, composites and adhesive applications in various industries. TechnipFMC's operating center in Lyon, France will license the Epicerol technology.

**BASF completes sale of its Mexican oleochemical surfactants business to Stepan**

March 27, 2018 — BASF has closed the sale of a portion of its oleochemical surfactants business in Mexico to Stepan CDMX, S. de R.L. de C.V., a subsidiary of Stepan Co. (Northfield, Ill.; www.stepan.com). The transaction includes the Mexico oleochemical surfactants product portfolio and intellectual property, as well as the production assets at the Ecatepec site in Estado de Mexico.

**AkzoNobel sells Specialty Chemicals business for €10.1 billion**

March 27, 2018 — AkzoNobel (Amsterdam, the Netherlands; www.akzonobel.com) announced the sale of 100% of its Specialty Chemicals business to longstanding investment partners The Carlyle Group and GIC for an enterprise value of €10.1 billion. The transaction is expected to be completed before the end of 2018.

**Hexcel and Arkema to collaborate on aerospace composites**

March 26, 2018 — Hexcel Corp. (Stamford, Conn.; www.hexcel.com) and Arkema (Colombes, France; www.arkema.com) have signed a strategic alliance to develop thermoplastic composite solutions for the aerospace sector, combining the expertise of Hexcel in carbon fiber and that of Arkema in polyether ketone ketone (PEKK). As part of this partnership, a joint research and development laboratory, located in France, will be established.

**Tronox to sell Nevada-based electrolytic assets**

March 26, 2018 — Tronox Ltd, (Stamford, Conn.; www.tronox.com) has entered into a purchase agreement with EMD Acquisition LLC to sell certain assets and liabilities of its Electrolytic Operations business based in Henderson, Nev. for $13 million in cash, subject to certain working capital adjustments. The transaction is subject to customary closing conditions and expected to close mid-2018.

**Alpek, Indorama and Far Eastern to acquire M&G's Corpus Christi project**

March 22, 2018 — Corpus Christi Polymers LLC — a newly formed JV between Alpek S.A.B. de C.V. (San Pedro Garza Garcia, Mexico; www.alpek.com), Indorama Ventures Public Ltd. (Bangkok, Thailand; www.indorama.net) and Far Eastern Investment Holding Ltd. — has entered into an agreement to acquire M&G's integrated purified terephthalic acid (PTA) and polyethylene terephthalate (PET) plant that is currently under construction in Corpus Christi, Tex., along with certain intellectual property and a desalination and boiler plant. When completed, the plant will have a nominal capacity of 1.1 million m.t./yr of PET and 1.3 million m.t./yr of PTA. The plant is expected to be the largest single-line vertically integrated PTA-PET production facility in the world. ■

*Mary Page Bailey*

# Refinery Responsiveness Front and Center

Responsiveness and adaptability — in the face of shifting market forces, new regulatory policy and natural disasters, among others — framed the discussions of U.S. petroleum refiners at the AFPM annual meeting

## IN BRIEF



Responsiveness and adaptability for U.S. petroleum refiners emerged as a theme at the most recent annual meeting of the American Fuel and Petrochemical Manufacturers (AFPM; Washington, D.C.; www.afpm.org) in New Orleans, with those concepts framing many of the discussions and presentations at the meeting. While the overall mood of refiners and petrochemical producers is generally very positive, there are a number of developments that require industry players to respond and adapt, both to take advantage of new opportunities and also to avoid potential problems.

**FIGURE 1.** Restrictions on sulfur content for marine fuels will likely widen price differentials between sweet and sour crude oils and between light and heavy crudes

For example, the effects of increased crude petroleum production from U.S. shale deposits, coupled with the effects of the higher crude exports over the past two years, are still resounding throughout the refining and petrochemical sectors, forcing refiners to strategize based on a new set of rules for the crude oil landscape. In addition, refiners are looking for ways to respond to impending restrictions in the amount of sulfur permitted in marine fuels. Further, the refining industry must formulate strategies for responding to differentials in demand growth for transportation fuels compared to chemical precursor products.

Another manifestation of the "responsiveness and adaptability" theme was in discussions at the AFPM meeting of plant-level responses to natural disasters — petroleum refinery and petrochemical facility executives shared stories of resilience from Hurricane Harvey's aftermath (see sidebox, p. 16). This article describes several of the major issues that are pushing companies and facilities to adapt and respond, and what the wider implications may be for the industry.

### Ripple effects from shale and exports

Along with dramatic increases in oil and natural gas production from the "shale boom" in the U.S., the lifting of export restrictions on crude oil for U.S. refiners in December 2015 led to seismic shifts in crude-oil markets and petrochemical production across the globe. These shifts continue to shape petroleum refining conditions in 2018 as their effects ripple outward. Although the news is generally good for U.S. refineries, these ripple effects are requiring that refiners respond to a much different global reality than was the case a few years before.

"The effects of the decision to allow U.S. crude oil exports are still echoing in 2018, and still working themselves out," comments Mark Routt, chief economist for the Americas at KBC Advanced Technologies Inc. (KBC; Houston, Tex.; www.kbcat.com). According to AFPM's 2018 annual report, the U.S. currently now exports nearly 80 billion barrels (bbl) of crude petroleum per month, most of it light, sweet crude from shale deposits in West Texas and New Mex-

**FIGURE 2.** Projected fuel-efficiency gains for advanced internal combustion engines and a greater number of electric vehicles on the road could flatten demand growth for gasoline in the longer term

ico destined for Europe, Latin America and Asia. Since the crude export restrictions were lifted in 2015, the increased exports have allowed the glut of oil "trapped" in the U.S. to "drain" out of the country. Many forecasts, such as one from the International Energy Agency (IEA; Paris, France; www.iea.org), predict that U.S. crude oil exports will become a net oil exporter within the next several years (and a net natural gas exporter sooner than that).

In general, the increased petroleum production and freed crude exports have favored U.S. refineries and petrochemical manufacturers. AFPM president Chet Thompson pointed out that refinery utilization in the U.S. is at 90%, and petrochemical exports from the U.S. are up 60% in two years.

However, the fortunes of individual refiners depend on their ability to adapt quickly to dynamic market conditions and government policies. "Refiners need to be nimble," says Mark Routt, of KBC, because "the situation is constantly changing and often rapidly."

Crude oil transportation infrastructure, including pipelines, shipping terminals, docks and others, plays a key role in refinery strategies and decisions. For example, numerous announced pipeline and terminal projects in Corpus Christi, Tex. could allow significantly more crude oil from the Eagle Ford and Permian shale plays to be stored and shipped from there.

## Low-sulfur marine fuels

Among the prominent topics at AFPM was the petroleum refining industry's response to regulatory policy that restricts the levels of sulfur in marine fuel (Figure 1; also known as bunker fuel; a heavier, higher-boiling-point fraction of crude oil than gasoline and diesel fuel that is burned for power). In late 2016, the International Maritime Organization (IMO; London, U.K.; www.imo.org), an agency of the United Nations, decided to imple-

ment a tighter schedule for restricting sulfur from stacks on ships. The ruling requires that ships use bunker fuel that contains 0.5% sulfur residue by 2020, rather than by 2025. The current sulfur cap on bunker fuel is 3.5% residual sulfur.

The impending cap on sulfur content has implications for refineries because bunker fuels will be based on petroleum distillates, rather than fuel-oil fractions. "While the future for the refinery sector looks good globally, the IMO restrictions represent a big question mark," because of uncertainties over how to find uses for the displaced high-sulfur fuel oil, explains John Mayes, a consultant at the firm Turner & Mason (Dallas, Tex.; www.turnermason.com). Other questions are also raised, such as whether refiners will add desulfurization capacity, and to what extent exhaust gas scrubbers will be installed on large ships to allow them to burn high-sulfur fuel oil and remain in compliance. There is also some uncertainty surrounding the details of how the regulation will be enforced.

To date, very little progress has been made by the refining sector, in terms of new construction, to deal with the sulfur limits brought about by the IMO decision, Mayes says. And any projects started now to increase capacity to process high-sulfur feedstocks into compliant fuels likely will not be completed by the 2020 date when the restrictions go into effect.

According to an analysis by KBC, the IMO cap on sulfur content in marine fuel will "widen the price differentials between light and heavy crudes and between sweet and sour crudes." Further, "prices of sweet crudes will go up, while sour crude prices will go down," says Mel Larson, principal consultant at KBC. "High-sulfur fuels will eventually be phased out entirely and low-sulfur fuel will be the only viable option."

The shift to low-sulfur marine fuel will also require upgrading investment by refineries to cut high-sulfur fuel oil (HFSO) production and upgrade product yields. The end result is a high probability that more than 2 million bbl/d of HFSO will be stranded in the market because of this decision," KBC's Routt says. KBC projects that HFSO prices will drop to close to coal prices. "The effect on refinery margins depends on the percentage of exposure in the HSFO market," the analysis states. Opportunities for refineries to optimize their crude diets and increase coker utilization may arise from these developments. On the other hand, low-complexity refineries are exposed to a number of risks.

There will be a large need to find a home for bottoms fractions, because it will be more difficult to use them in the pool of marine fuel oil fuels, Larson says. U.S. refiners need the ability to process bottoms with high-sulfur content.

"The most obvious refinery response [to the surplus of HFSO] would be coking," Turner & Mason's Mayes explains, because coking can crack some of the long chains into more marketable fuels. "Refineries that have coking operations will do well, but there will still be too much fuel oil to use in the available cokers, so it will need to find other uses," he comments. Mayes also comments that large volumes of low-sulfur distillates and gas oil will be blended into the bunker fuel pool to reduce overall sulfur content, which will lead to a spike in demand for these distillates.

Ships can install onboard scrubbers, but they are costly and there is uncertainty in the marine shipping sector about whether or not scrubbers are worth the investment. The alternative is to burn low-sulfur fuel oil on ships, so the demand for sweet (low-sulfur) crude oils will rise.

## Fuel quality and octane

In addition to responding to changes on the marine fuels, U.S. and international petroleum refiners are also addressing changes in fuels for land vehicles, including several parallel trends that could reduce future demand for gasoline.

Among these trends are a rising number of electric-powered vehicles, improved higher-efficiency internal combustion engines, and more "mobility-as-a-service" businesses (including car-sharing and others; Figure 2). At the AFPM meeting, General Motors (New York, N.Y.; www.gm.com) vice president for global propulsion systems Dan Nicholson outlined these trends, all of which have the effect of modulating demand growth for gasoline and diesel fuel.

### RESPONSE TO HURRICANE HARVEY 2017

In keeping with the refinery response theme, AFPM attendees took a look back to August 2017, when Hurricane Harvey caused flooding on a massive scale along the Gulf Coast and in Houston. It was pointed out at the meeting that Hurricane Harvey impacted 60% of U.S. petrochemical production and 25% of refining capacity, according to AFPM, in addition to ports, terminals, rail stations, pipelines and other infrastructure. However, the recovery was rapid, with 20 of 24 refineries shut down because of the storm restarted within two weeks of Harvey's landfall. And 70% of petrochemical production impacted by the storm was resumed within of three weeks of the Hurricane, according to AFPM.

In a special panel session, several executives from plants near Houston that were affected by Hurricane Harvey talked about how the storm affected their facilities and employees and how their response was mounted. The following are points made by panelists at the session.

- These industry sectors to strive to "harden" their facilities against natural disasters.
- Setting up emergency command and communication centers is a good strategy for getting through the event
- Mobility challenges (flooded roads, and so on) are likely during a natural disaster, and can have a large effect on employees' ability to get themselves to the plant
- Taking care of affected employees is important. Reserving hotel rooms before a storm, making grants and no-interest loans to employees can be big helps for those that are heavily affected
- It is helpful to work with local police and fire forces on monitoring and security needs for the facility during and immediately after the storm
- Hurdles to coming back include restoring infrastructure outside the plant (docks, pipelines, railroad bridges, and so on); replacing equipment, replacing instruments, ensuring supplies of hydrogen, nitrogen and others required materials; remediating mold, and others
- The lesson is "you can't be overprepared"
- Drone technology can be helpful in emergency response
- Communication with federal government was better than previous with this storm

He stressed that internal combustion engines will not disappear any time soon, but that going forward, vehicle engines will pursue efficiency gains and will require gasoline with higher octane numbers. Nicholson pointed out that 95 RON (research octane number) may be optimal for many of the future engines. Today's premium gasoline is typically 93 RON and regular gasoline is 87.

Because of these changes, refiners must find ways to maximize octane numbers and boost yields of premium gasoline in their product slate, even as they keep a close watch on gasoline and diesel demand. Alan Gelder, senior analyst for Wood Mackenzie (London, U.K.; www.woodmac.com) says that, along with the IMO decision, maximizing octane is the biggest issue for refiners right now.

"[Corporate average fuel economy (CAFE)] standards on vehicle efficiency are driving up the demand for higher-octane fuels," he says. "Everyone is going to want premium gas." He adds that if gasoline demand declines, refiners must think through their options.

A few announcements at the AFPM meeting may have relevance to questions of rising octane needs. One solution, presented by New Gas Technologies (NGT; Houston, Tex.; www.ngts.us), is the first commercial methaformer, which combines methanol with naphtha to yield sulfur-free, high-octane gasoline at much lower costs than catalytic reforming and isomerization, the conventional route. To read more about this technology, see the Chementator section of this issue, p. 7).

Another related development for diesel fuel quality involves a new hydrotreating catalyst from Honeywell UOP (Des Plaines, Ill.; www.uop.com) designed to allow refiners to convert lower-value diesel blending components into fuels that meet more stringent fuel-quality specifications. For more information on this new catalyst, see the Chementator section of this issue, p. 7.

## Oil-to-chemicals strategies

Because of planned improvements in engine efficiency for new vehicle fleets and the growth of alternative vehicle propulsion technologies, demand growth for common transport fuels is not expected to be strong over the longer term, many industry watchers say. In contrast, demand for petrochemical products is projected to see much greater demand growth, driven by global population increases, improving living standards and demographic shifts from rural to urban areas.

In response to this market scenario, petroleum refiners are thinking more broadly and strategically about converting crude oil into consumable products, rather than fuels (Figure 3). This includes compounds such as olefins, polyols and aromatics, that have not generally been a focus of refiners' normal product range. "This imbalance has made the idea of using crude as a direct feedstock more appealing," says Clyde Payn, CEO of The Catalyst Group (Spring

**FIGURE 3.** To take advantage of growth in petrochemical markets, refiners are exploring configurations to allow direct production of petrochemical products and petrochemical feedstocks from crude oil

House, Pa.; www.catalystgrp.com).

"In the past, the mindsets of refiners and petrochemicals were completely separate — while the former was geared toward commodity products, the latter was focused on specialty product markets," explains KBC's Mark Routt. As time went on, refinery-petrochemical integration (RPI) became a tool to improve refinery margins. But a "third phase of RPI is just beginning now," Routt says, in which engineers are "designing refining and petrochemical capacity in an integrated way from the beginning, to give manufacturers as much optionality as possible."

While RPI is not a new concept, the novelty is in "orienting the refinery portion of a complex specifically to produce petrochemicals or feedstocks for petrochemicals," explains Jerry Price, senior consultant at Jacobs Engineering Group (Dallas, Tex.; www.jacobs.com). "One is able to utilize the chemistry of proven refining and petrochemical technologies to maximize the value from each stream in the facility."

At the AFPM meeting, Price discussed the possibilities of oil-to-chemicals (OTC) strategies, as well as his company's offering, known as Jacobs C2C (crude to consumables), which focuses on "getting the right molecules into the right process units to maximize value," he says. Among the petrochemicals figuring prominently in these strategies are olefins (ethylene and propylene), aromatics (benzene, toluene and xylenes) and special intermediate streams like C4 compounds and higher olefins.

One example of an OTC concept that Jacobs has explored significantly is high-propylene-yielding configurations utilizing steam cracking in conjunction with a residue fluid catalytic cracking (RFCC) unit. "In certain instances, these configurations could yield up to 12–15 wt.% propylene on crude for the overall complex," Price says.

Speaking more generally, KBC's Mark Routt cites another example of how to create refinery-petrochemical integration with heat-exchange and steam systems. "Refinery operations tend to require a great deal of heat, so they have elaborate heat-exchange systems, as well as different steam pressures and so forth," Routt says. "Petrochemical manufacturing needs more rotating (motive) energy, which creates opportunities for integration between the two," he says. For example, "you could take steam and pass it through a gas-condensing turbine and turn that steam, which is thermal power that a refinery uses, into motive energy for use in petrochemical production processes."

Within the context of OTC, "lighter crudes containing higher levels of naphtha have an inherent advantage over heavier crudes, because they can achieve significant conversion to petrochemicals while reducing the capital investment required to convert the vacuum gas oil (VGO) and residue portions of the crude into naphtha or naphtha-like streams," Price says.

## RPI investment decisions

Oil-to-chemicals can be a complicated undertaking, because many needs should be considered. This includes not only choosing "the appropriate configuration to make the right products," but also "building in an optimal location, licensing the most suitable technologies, finding investors to finance the project, and selecting an experienced contractor to construct it," Price remarks.

Making investments in OTC strategies requires companies to look closely at their inherent competitive advantages. "Do they have access to cheap crudes or other feedstocks that could be utilized in a new refinery-petrochemical-integrated facility? Do they have a captive market or industry that can utilize the products? How are they positioned with respect to competition in the fuels or petrochemical market? These are the types of questions one should consider before pursuing an OTC investment," Price says.

"While a grassroots opportunity allows one to start with a blank sheet and explore all possibilities, revamping an existing fuels-oriented refinery is certainly possible," Price says. The latter is a more complex proposition, requiring a higher level of knowledge of both the refining and petrochemical processes, he explains. Because of this, Jacobs has cultivated expertise in developing novel configurations, and remains technology-neutral to avoid being tied to a particular portfolio of process technologies.

An example of a grassroots effort is the development of the world's largest fully integrated OTC complex in Saudi Arabia. Late last year, Saudi Aramco and SABIC signed a deal to build a $20-billion OTC complex. The complex is expected to process 400,000 bbl/d of crude oil and produce approximately 9 million ton/yr of chemicals and base oils.

In evaluating OTC strategies, refiners must weigh the additional capital and operating expenses against the potential improvements in internal rate of return, along with the company's appetite for business risk and ability to raise funding, Price says. ■

*Scott Jenkins*

# A Spotlight on Catalyst Supports

Fundamental research, using a huge arsenal of analytical and material-characterization tools, is yielding new and improved catalyst supports

## IN BRIEF



Readers of this magazine certainly understand the importance of catalysts in the chemical process industries (CPI), where they are used for speeding reactions, moderating operating conditions and minimizing the formation of byproducts. Although some types of catalysts provide their own mechanical strength (the so-called bulk catalysts, such as metal gauzes and foams and amorphous oxides), a large class of catalysts are dispersed onto the surface of a support material, and the support is as important as the catalyst itself. Therefore, making a catalyst system for a commercial production process requires the development of the complete package — catalyst plus support. For this reason, catalyst suppliers are actively working on both simultaneously, tailoring the catalyst system for each and every application. And this entails fundamental research and modeling of surface chemistry coupled with advanced analytical tools for measuring physical properties (Figure 1), such as porosity, surface area, particle size, and more. Presented here are some examples of recent developments in catalyst supports.

*ThruPore Technologies*

**FIGURE 1.** A large number of different analyzer tools are used to characterize catalyst supports. Shown here, for example is an automated chemisorption analyzer being used to determine porosity and surface area of carbon supports

### Types of supports

"The term 'catalyst support' is maybe a bit misleading and for sure underrating its role for a catalytic reaction," says Marvin Estenfelder, head of R&D at Clariant's BU Catalysts (Munich, Germany; www.clariant.com). Generally, the term "support" is used with two very different meanings, explains Estenfelder: "In some reactions and applications — like selective oxidations — a non-active support is used to provide a geometrical structure for the active material that is coated in a thin layer onto it. In such cases, very often ceramic materials like steatite or cordierite are used and the support typically has very low porosity and surface area. It is nevertheless required since a fully body of the active material would be too active and too much heat would be released during reaction, leading to a dangerous 'runaway.' Due to a lack of reactive surface groups, such supports require specific binders to attach the active layer tightly onto its surface. A specific example is the selective oxidation of *o*-xylene to phthalic anhydride. Interestingly, the ceramic structural support applied is coated with an active layer which itself consists of a titania support on which the active species vanadia is spread. Clariant's PhthaliMax series combines high physical strength and adherence of the active layer to the support, as well as a tailored activity pattern providing highest selectivity and yield."

"In the second group of reactions, the catalyst support offers a high surface area to which the catalytically active material is affixed," Estenfelder continues. "It is important to mention that the role of the support in those cases goes beyond the deposition of the active material on it. The catalyst support plays a pivotal role for most catalytic transformations itself by either adsorption of reactants or intermediates, including spillover

Haldor Topsøe

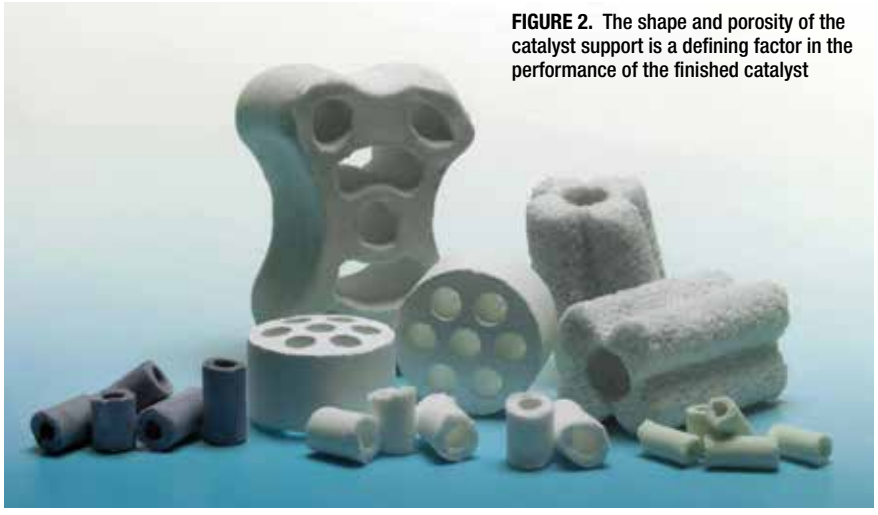


**FIGURE 2.** The shape and porosity of the catalyst support is a defining factor in the performance of the finished catalyst

effects from or to the active sites, by activation of the substrates by, for example, polarization or (de)protonation or by inducing unwanted side-reactions. Keeping this in mind, two things become quite clear: 1) each development of a catalyst is inseparably connected to the development or at least tailoring of the support for the specific reaction; and 2) as there are many ways a catalyst support may influence the catalytic reaction, there is no main characteristic of a support material but all of them have to be optimized at the same time," says Estenfelder. "The support material is one integral part of the catalyst and with each new catalyst developed, a new or modified support tailored to the specific application is used."

"It is essential that the catalyst support is compatible with the reaction conditions for the particular catalytic process so that the support does not undergo any kind of chemical change," says Michael Brorson, senior expert at at Haldor Topsøe A/S (Lyngby, Denmark; www.topsoe.com). "Such change could be at the surface (for example, sulfatization of alumina in contact with SOx atmospheres), and this would affect the catalytically active phase dispersed on the surface. The change could also be in the bulk if the support material is not thermodynamically stable at process conditions; this will eventually lead to complete loss of integrity of the catalytic pellet or extrudate that could pulverize and lead to dramatic pressure drop increase in the reactor," says Brorson.

Topsøe has developed sour shift catalysts — water-gas-shift catalysts that can be operated in high-sulfur atmospheres, which poison the usual copper- and iron-based shift catalysts. Such atmospheres are encountered when processing downstream gases from coal or petcoke gasification. The active phase in these sour shift catalysts is cobalt-molybdenum-sulfide and is similar to the active phase of hydrodesulfurization catalysts used in oil refineries, explains Brorson. But while the hydrodesulfurization catalysts have aluminum oxide as support, this material is not compatible with the steam content of gasification gas. Topsøe's sour shift catalysts are therefore supported on high-surface-area magnesium aluminum oxide, which is stable in steam.

## Ceramic supports

For a given support material, there are typically three parameters to optimize when it is shaped into pellets or extrudates (Figure 2): surface area, pore size and pore volume, says Brorson. These parameters are geometrically interlinked, so the optimal combination will always be a compromise. For example, a very high surface area is good for dispersion, but tends to imply small pores and consequently diffusion restrictions, explains Brorson. Also, while a low pore volume will lead to high packing density of the catalytic pellets or extrudates, which is good for increasing catalyst volume activity or reducing reactor volume, it may have disadvantages in the catalyst production process.

"In recent years, Topsøe's continuous R&D efforts have enabled us to modify our in-house manufactured aluminum oxide precursor materials for producing aluminum oxide supports," says Brorson. "This has allowed us to increase porosity and, with that, improve the impregnation with active metals."

## Active supports

While some supports must remain inert, others can play an important role by participating in the reaction. A good example of this is the catalyst system used for controlling emissions from gasoline engines. Gasoline emissions control requires the simultaneous conversion of hydrocarbons (HCs), CO and NOx under fluctuating conditions, explains Nicola Collins, principal scientist at Johnson Matthey Plc (JM; London, U.K.; www.matthey.com). Unlike diesel, which is always lean (oxidizing), gasoline is a stoichiometric exhaust with fluctuations between rich (reducing) and lean conditions. Therefore, we use a ceria zirconia support, where the ceria also serves as an oxygen-storage material. Under difficult reducing conditions, the $Ce_2O_4$ releases $O_2$ for oxidizing the HCs and CO; under difficult oxidizing conditions, the $Ce_2O_3$ captures $O_2$, enabling the destruction of NO, says Collins. Although this system has been commercial for a long time, there continues to be work on improvement, she says.

Another example of the support playing a role in the catalyst system was described in *Nature Communications*, published in February. There, researchers from the Ruhr-Universität Bochum (RUB; www.ruhr-uni-bochum.de), the Max Planck-Institute for Energy Conversion (Mülheim, both Germany) and Pacific Northwest National Laboratories (Richland, Wash.) describe a DuBois-type-complex fuel-cell catalyst they developed that features a self-defense mechanism against $O_2$ — a deactivating catalyst poison.

To do this, the scientists introduced a hydrophobic and redox-inactive polymer as immobilization matrix for the nickel-complex (DuBois-type) catalyst. By embedding the catalyst into

Haldor Topsøe

**FIGURE 3.** Topsøe's VK catalyst for the production of sulfuric acid and sulfur removal is based on a 12-mm daisy-shaped carrier. This shape improves energy efficiency due to low initial pressure drop

the polymer matrix, two separated reaction layers form: a catalytically active layer close to the electrode surface and a protection layer at the polymer-electrolyte interface. The first layer allows for an efficient conversion of $H_2$ at the electrode surface and the second layer removes incoming $O_2$ at the interface and thus protects the active layer from oxygen damage.

## Supported liquids

The century-old vanadium-based $SO_2$-to-$SO_3$ oxidation catalysts used for manufacture of sulfuric acid contain a supported liquid consisting of vanadium oxide dissolved in alkali metal pyrosulfates, says Topsøe's Brorson. The liquid is dispersed in the pore system of silicon dioxide support pellets. Reactions take place by diffusion of $SO_2$ and $O_2$ into the melt, where they catalytically react to form $SO_3$, which subsequently diffuses out of the melt.

Using *in situ* transmission electron microscopy, Topsoe researchers have shown that the melt dynamically redistributes over the silica carrier surface in ways depending on temperature and precise melt composition. The latter depends on both the fixed metal concentrations and the more variable composition of the gaseous atmosphere that partially dissolves into the melt, as reported in a 2016 issue of *J. Phys. Chem*.

On convex carrier surfaces in the pore system, the melt sometimes partially crystallizes while concave surfaces accumulate liquid by melt migration. "This knowledge has been used for the development of an improved carrier (Figure 3) used for Topsoe's new VK-711 Leap5 catalyst, says Brorson.

At Clariant, "we have been working for quite a while on the very promising concept of supported ionic liquids," says Estenfelder. "Both sub-concepts SILP (supported ionic liquid phase — supported homogeneous catalysts dissolved in an ionic liquid dispersed on a support) and SCILL (solid catalyst with an ionic liquid layer) — heterogeneous catalyst with an ionic liquid as reaction promotor) show great promise for industrial application," he says. "We are working on various applications together with partners and customers, for example, on the water-gas-shift reaction. For the final commercialization, some important questions still have to be answered, he says. "We have made good progress and we are in the final stage of evaluation for one development."

Researchers at Evonik Industries AG (Essen, Germany; www.evonil.com) are also developing SILP catalyst technology for hydroformylation reactions (see *Chem. Eng.*, October 2015, pp. 18–24).

## Carbon

There are some reactions for which only carbon can be used as a support, says Franchessa Sayler, CEO at ThruPore Technologies, Inc. (New Castle, Del.; www.thrupore.com). "Hydrogenation reactions use carbon — there is no alternative," she says. Conventional carbon supports are made by mixing carbon particles with a binder and then extruding to form pellets. Such carbon supports have a high surface area, as measured by traditional methods, but when viewed under a microscope, the active metal tends to simply sit on the outside, so only the outer surface of the surface is used. Such pellets also suffer from attrition issues, explains Sayler. "We have taken synthetic carbon and introduced a high degree of porosity, via a proprietary process," says Sayler.

Normal carbons are either natural-product based or residues from petroleum refineries. Traditionally, the best source of carbon material had been coconut shells, which have more porosity than alternatives, explains Sayler. But because they are derived from biomass, that carbon also contains traces of nitrogen, phosphorous and sulfur, which can poison a catalyst, she says. "We use a chemical method to get carbon with a very low ash content and no sulfur or other catalyst poisons."

ThruPore Technologies was co-founded by Sayler and professor Martin Bakker in 2012 at the University of Alabama. As a graduate student, Sayler figured out how to control the pore size of a catalyst's support structures, creating 50% more accessible surface area. "We can put any precious metal catalyst on the support, but we first started with palladium on carbon,

Johnson Matthey

**FIGURE 4.** Additive manufacturing (-D printing) is being used for producing sintered ceramic supports (made of two different ceramic materials) with open geometries, which may find applications in mass-transfer-limited surface reactions

because this is an important industrial catalyst for hydrogenation reactions," she says. ThruPore's C/Pd catalyst is six times more active than existing catalysts, and requires 30–50% less precious metal to achieve the same performance, she says.

ThruPore has formed a manufacturing partnership with Inventure Renewables, Inc. (Tuscaloosa Ala.). Current production is approximately 20 ton/yr, and the next step will be 100–200 ton/yr, says Sayler.

## Control of particle size

In slurry-type polymerization reactions, the size of the catalyst support can be an important parameter. Evonik has recently introduced its latest generation of Catylen Ziegler and Ziegler-Natta catalyst, Catylen S 300, which features a magnesium ethanoate support material that is produced in precisely the required particle size. The size can be selected within a range of 18 to 80 µm — up to 20 times smaller than the support material of its predecessor, Catylen S 100, according to Budo Richter, head of R&D Olefin Polymerization Catalysts. The particle size distribution can be controlled to within ±1 µm.

## 3-D printing

For the last few years, Johnson Matthey has been developing 3-D printing (additive manufacturing) as a forming procedure to create experimental ceramic shapes that were previously unobtainable using traditional forming methods, like extrusion or pelletization, says Alex Munnoch, a research scientist at JM. "With this technology, we can control internal features and spatial distribution through a 3-D printed structure; such structures could then be utilized in combination with active catalyst materials, which could be incorporated through a variety of traditional methods, such as impregnation, precipitation, and coating," he says.

"At the moment, we are focusing our research on the powder bed binder-jetting method, where we start with a 3-D model using CAD, [computer-aided design] and then use an ink-jet type printer to print 2-D slices of the shape onto successive thin layers of ceramic powder to create the final 3-D structure of the support precursors, layer by layer. The subsequently sintered structures have a complex shape with a high geometrical surface area, making them industrially important for mass-transfer-limited surface reactions, where the amount of active material matters," says Munnoch. "Notably, the heat/mass-transfer know-how developed as part of our heat-exchanging structured Catacel technology complements our additive manufacturing R&D."

"Although the printed materials are very open and look fragile, these sintered ceramics have comparable strength to existing supports," he adds. "The combination of our R&D printers and our demonstration plant allows us to produce multi-tonn quantities whilst maintaining flexibility of materials and designs, he adds. ■

*Gerald Ondrey*

# Advanced Liquid Analytics Aid Process Optimization

## Digitalized, cost-effective instruments allow more measurement points and provide usable data

### IN BRIEF



Although the basic methods of measuring pH, oxidation-reduction potential (ORP), conductivity, dissolved oxygen (DO), chlorine, turbidity and similar parameters haven't changed, digitalized instrumentation for liquid analysis is becoming smarter, easier to use, more cost effective and adaptable to demanding applications. But, what do these improvements bring to the table for chemical processors? More measurement points can be added, allowing processors to make the shift from simply monitoring a process to quickly collecting actionable data that can be used to reduce and simplify maintenance and optimize the plant.

"Processors have always used sensor measurements for liquid analysis, but it's how they currently are using data from these measurements that's changing," says Tracy Doane, national product manager, Analytical, with Endress+Hauser (E+H; Greenwood, Ind.; www.us.endress.com). "We are seeing more measurement points installed into critical parts of their processes because it provides knowledge about how the process is operating, which often leads to economic improvements to the business. At the end of the day, processors don't care about a pH sensor, they care about improving the metrics of the organization, so they are using the data from these instruments to look for actions they can take to help lower costs, improve product purity, remove bottlenecks, find higher throughput and provide increased safety to plant, personnel and the environment."

Doane continues: "This is now possible because we are able to digitize today's more intelligent sensors and transfer collected information to where it can be accessed and used to help optimize processes."

Eric Kim, international sales manager/applications engineer, with Electro-Chemical Devices (ECD; Anaheim, Calif.; www.ecd-analytical.com), adds that the ease of use and cost effectiveness of today's analytical

*Endress+Hauser*

**FIGURE 1.** The CA80PH is an analyzer that offers online orthophosphate measurement for precise dosing of precipitants in wastewater treatment

instruments are also boosting the ability to use measurements in this fashion. "In the past, liquid analytics was primarily done using grab samples, which had to be taken to a lab. This was time-consuming, expensive and slow," he says. However, processors want results immediately so they know promptly whether to make adjustments that help optimize the process. "For this reason, there's a trend to make the instruments not only smarter, but also more user-friendly and cost-effective, allowing them to take more measurements throughout the plant and get faster, more reliable results," Kim explains.

Cherlyn Marlow, product manager for process liquid analyzers with Yokogawa Corp. of America (Newnan, Ga.; www.yokogawa.com/us), adds that these trends not only allow more widespread use of liquid analysis for process optimization, but also new applications for the instruments. "Chemical plants are continually adding more online measurements, but I have also seen many


**FIGURE 2.** T80 Universal Transmitters are designed for the continuous measurement of pH, ORP, DO, turbidity and more. The transmitter digitally communicates with an S80 Intelligent Sensor, automatically configuring the transmitter's menus and display screens to the measured parameter

new applications," she says. "When it comes to the liquid analyzer world, there are so many opportunities for process improvements. We have also seen companies looking internally to reduce their waste and recycle back into the plants or use their waste for another process. But to do any of these, they usually need to add more analyzer instruments."

## The digital revolution

In the past, processors ran sensors to failure, explains E+H's Doane. "So while they had to measure pH and other parameters, it was not always a trustworthy measurement if a sensor was close to failure." However, she says, the digital age has allowed users to start trusting and relying on measurements so they can be used for validation and verification, right on through to the production phase, where these measurements can be applied to control and tweak the process. "There's been a huge paradigm shift from monitoring liquid measurements to actually controlling processes with these measurements. This is due to the ability to digitalize information from the sensor and pass it to the transmitter and then out into the DCS [distributed control system] to the higher levels of the organization where business decisions can be made based upon the available data. Thanks to digitalization, liquid analytics can be part of Industry 4.0 and big-data analytics."

To facilitate this capability, E+H applies Memosens technology to liquid analysis instruments (Figure 1), which converts the measured value to a digital signal and transfers it to the transmitter. Memosens offers signal alarms if there is a transmission disruption to provide safe data transfer and increased availability of the measuring point. The digital sensors store calibration, sensor and process data, allowing calibration and regeneration under laboratory conditions for increased sensor life and minimal process downtime. Meshing with Memosens sensors is Liquiline transmitter technology, which serves as a platform for all liquid analysis applications. Memosens sensors can be quickly connected to the Liquiline transmitters, which automatically recognize the sensor type and read the information stored in the sensor. The transmitter also offers integration into process control systems via 4–20 mA, HART, Profibus DP, Modbus and Ethernet. In addition, the company's Heartbeat Technology, offered with its liquid analysis devices, organizes

Shimadzu


**FIGURE 3.** The online TOC analyzer, the TOC-4200 offers a selection of sampling techniques from a single-stream sampler to a sample exchanger for six different sample streams without a homogenizer for water containing particles

standardized diagnostic messages of what needs to be done in order to maintain the instrument, enabling predictive maintenance and delivering evidence for operational reliability and process safety.

"The information available from these sensors, thanks to the digitalization, is a lot more important than just the pH, ORP or other measurements," explains Steven Smith, senior product manager, Analytical, with E+H. "We are now able to pull those data and get a wealth of information regarding the device itself, send it to the control system, incorporate it into the user's process information and deliver an added value to process engineers," he says. For example, looking at the parameters for the pH measurement might show users a deviation over time and, because they can view reports that show the sensor has been functioning properly, they know the deviation is likely due to the process itself, not the sensor.

Similarly, Yokogawa offers its Sen-

Thermo Fisher Scientific

**FIGURE 4.** The Vanquish Duo UHPLC system uses a separate second flow path in one integrated system. By having two flow paths in one instrument, users can double throughput or deepen sample knowledge by running the same method on both flow paths or two different methods simultaneously on one instrument

sation package solution, encompassing Data Acquisition and Smart digital Sencom sensors (such as the Sencom pH/ORP platform). In many facilities, liquid analyzers are connected to chart recorders and paper logbooks that are being used and maintained for registration, reporting and traceability. With Sensation, the capabilities of some of Yokogawa's products, such as Smart datalogger, SmartDac+ and Smart digital Sencom sensors, are combined to create a solution that will improve factory efficiency and profitability by improving the traceability and functionality and simplifying maintenance and calibration, notes Yokogawa's Marlow.

Sencom technology allows sensors to transmit and receive data when connected to the device. Digital or Smart sensors maintain the specific measurement and calibration data on an integrated chip. The data can be exchanged between the sensor and either a process measurement device or a laboratory PC via data management software. Using historical measurement, calibration and diagnostic data from the sensor, the data-management system provides the tools to predict maintenance and calibration frequency and estimate sensor life.

## Cost-effective, easier-to-use

In addition to the diagnostic capabilities and ability to digitally transfer collected sensor information, cost effectiveness, ease-of-use and flexibility are facilitating increased use of liquid analytics.

"In the days of analog signals, the transmitter display showed only the measurement," notes ECD's Kim. "But now as the costs are coming down and digital transmitters are able to provide more data, including predictive maintenance and calibration information, users are getting much more bang for their buck, allowing them not only to add more measurement points, but to obtain more useful information at a lower cost."

Adding to the cost effectiveness is the flexibility of modern sensors and transmitters. For example, ECD offers a universal line of instruments for liquid analysis. T80 Universal Transmitters (Figure 2) are designed for the continuous measurement of pH, ORP, DO, turbidity and more. The transmitter digitally communicates with an S80 Intelligent Sensor, automatically configuring the transmitter's menus and display screens to the measured parameter. "For example, you can plug an S80 conductivity sensor into a T80 pH transmitter and it will automatically reconfigure into a conductivity transmitter," says Kim. "There is no longer a need to inventory multiple instrument types."

S80 Intelligent Sensors facilitate two-way communication with the T80 Transmitters. The type of sensor, identity and serial number are stored in the sensor's memory along with calibration registers. The sensors are calibrated at the factory, so they are ready to use when connected to a T80 transmitter. The S80 sensors also offer replaceable electrode cartridges. "This means that, if needed, only the electrode can be replaced and not the complete sensor, saving

the cost of having to replace the whole sensor. Also, if I buy a pH electrode for my S80, the transmitter will recognize it as a pH sensor, but if I later want to measure ORP, I can remove the pH electrode, replace it with an ORP electrode and the T80 transmitter will recognize it as an ORP sensor," he says. "Because users only have to purchase an electrode instead of replacing the whole sensor, it saves money."

ABB (Lewisburg, W.Va.; www.abb.com) is also building cost effectiveness and ease-of-use into instruments via a modular approach, says Nikodem Siwek, local continuous water analyzer product manager. "The main highlight of today's digital instruments is the ability to store the characteristics of the sensor on the sensor itself. This allows a mix-and-match approach and simplifies tasks, such as calibration, because you can essentially take the sensors out of the process, bring them to the lab and perform the calibrations all at once, then put them back in the installation easier and faster than before," he explains.

ABB is preparing to launch a new range of transmitters and pH/ORP sensors later this year that will offer this modularity. "Think of it as a box-built type design," he says. "You will have a shell of a transmitter with precalibrated modules that can be mixed and matched. This allows users to stock the transmitter and electrodes and then mix and match them depending upon the requirements at the time, improving flexibility of stocking, lowering overall costs and simplifying use."

## Evolving to meet demands

Often in the chemical industry there are demanding applications — either those with extreme process conditions or those that require swifter sampling techniques or niche instrumentation — and instrument providers are devising innovative solutions for these situations, as well.

For example, Jason Dalebroux, director of product management for Rosemount liquid and combustion analysis with Emerson (Shakopee, Minn.; www.emerson.com), says, "Any time you have an extreme application — those with high temperatures, high pressures or dirty conditions — better measurement methods are required. There are several solutions available on the market today to address more difficult process conditions and prolong sensor life."

He explains that most manufacturers offer re-buildable sensors so users can cost-effectively change the electrolytes and recharge pH sensors used in higher temperatures, as well as sensors built with more resistant materials so sensors operate longer without clogging in high suspended-solids environments. "We are also seeing new types of instruments, such as optical-based technologies, for measuring concentrations and substances within a liquid," says Dalebroux.

The Rosemount Analytical RDO optical dissolved oxygen sensor and analyzer, for instance, is more resistant to fouling than polarographic sensors, an important advantage in wastewater where coating is a common problem. Less sensitivity to fouling means less need for cleaning

and reduced operating costs. "The big advantage here is that you're using optical measurement to extend the performance life of a sensor in very dirty applications," says Ryan Bowlds, Emerson's global product manager for liquid analysis. "Previous technologies would have led to plugging of the sensor if used in wastewater treatment or processing within the plant if high levels of suspended solids were present. Optical measurements are more resistant."

*"Any time you have an extreme application — those with high temperatures, high pressures or dirty conditions — better measurement methods are required."*

Jason Dalebroux, Emerson

While many of today's technologies are in-situ, sampling is still necessary in many applications. However, instrument providers realize the necessity of speeding up the measurement process and providing flexibility to afford efficiency of process.

For example, regarding total organic carbon (TOC) analyzers, it is becoming increasingly important for process control to obtain fast, continuous information on the organic pollution levels of waters, says Mark Janeczko, chemicals and energy marking manager with Shimadzu Scientific Instruments (Columbia, Md.; www.ssi.shimadzu.com). "TOC process analysis offers this possibility because the sample is fed continuously to the instrument for subsequent measurement. The instrument sends the analytical data to the control room, which can react promptly to any possible process changes."

An approach that includes various modules, kits and options provides added speed and flexibility to this measurement. Shimadzu's online TOC analyzer, the TOC-4200 (Figure 3), offers a selection of sampling techniques from a single-stream sampler to a sample exchanger for six different sample streams without a homogenizer for water containing particles.

And when it comes to high-pressure liquid chromatography (HPLC), used in niche applications, the instrumentation here is also gaining speed thanks to the introduction of ultra-high-pressure liquid chromatography (UHPLC) techniques that are able to handle multiple flow paths simultaneously in order to speed up results, says Carsten Paul, HPLC product marketing manager with Thermo Fisher Scientific (Germering, Germany; www.thermofisher.com). The Thermo Scientific Vanquish Duo UHPLC system (Figure 4) uses a separate second flow path in one integrated system, which saves time and cost per sample without compromising performance or ease of use. By having two flow paths in one instrument, users are able to double throughput or deepen sample knowledge because they can run the same method on both flow paths or two different methods simultaneously on one instrument, improving lab productivity, sample knowledge, bench space usage and overall return on investment, says Paul.

Liquid analytical devices are being used more now than in the past due to the advancement, reliability and cost effectiveness of the instruments, says Daniel Siddiqui, chemical industry manager with E+H. "Vendors and manufacturers are being asked to embed intelligence in these devices so they may be used for process optimization and to monitor the health of process and equipment," he says. "They are breaking down barriers on the analytical side by including analytics in automation for control and process safety monitoring." ■

*Joy LePree*

# Focus on Safety

MilliporeSigma

## Protect bioreactors from a variety of contaminants

Viresolve Barrier capsule filters (photo) protect against bioreactor contamination by removing a range of viruses, mycoplasma and bacteria from cell-culture media. These barrier filters are designed to provide high-flux and high-capacity virus filtration and ensure desired productivity without impacting cell culture performance or protein quality attributes. For example, these capsule filters provide ≥ 3.0 log removal of parvovirus, ≥ 6.0 log removal of mycoplasma, and sterilizing-grade protection from bacteria, according to the manufacturer. They are scalable from bench-scale through commercial-scale operations. Used directly in front of the bioreactor, or in a media-storage container, they help to reduce process downtime, safeguard the downstream drug supply and ensure patient safety. This product is the latest in the company's Viral Safety Assurance Program, which includes a variety of products and process solutions that prevent viruses from entering upstream processses, detect viruses in cells, raw materials and intermediates, and remove viruses in downstream processes. — *MilliporeSigma, the Life Science business of Merck KGaA, Burlington, Mass.*
**www.milliporesigma.com**

Honeywell

## Lightweight, stylish safety eyewear protects workers

This company recently expanded its portfolio of safety eyewear with the addition of three new product lines: the Uvex SVP 200, 300 and 400 Series (photo). The Uvex 200 safety glasses feature a low-profile, frameless design, which weighs just 15 g and provides a 10-base wrap-around lens for optimum coverage. The design is said to ensure a comfortable and secure fit, and the polycarbonate lens provides fog-free, scratch-free performance. The Uvex SVP 300 Series is dielectric and meets ANSI Z87.1 certification. The 400 Series provides additional features. — *Honeywell Industrial Safety, Atlanta, Ga.*
**www.honeywell.com**

Rite-Hite Barrier Systems

## Interlocking safety gate allows the use of mezzanine space

For many companies, the ability to make use of mezzanines to create additional storage area or work space within their facility provides both an untapped opportunity and a potential hazard. The GateKeeper Mezzanine Safety Gate (photo) is a reciprocating barrier. It provides a failsafe interlock system that creates a controlled-access area in which workers can safely load and unload items from a pallet on the floor. The gate is designed to be installed on the edge of a mezzanine, pick module or elevated platform. When the outer gate opens to allow pallets to enter the mezzanine level, the inner gate automatically closes, keeping workers out. When workers open the inner gate to retrieve the material, the outer gate is securely locked. The exclusive link-bar design ensures that both gates always work in unison, without relying on chains or cables. The system also includes a "toe board" design that prevents materials from accidentally being pushed off the mezzanine. Multiple sizes are available. — *Rite-Hite Barrier Systems*, *Milwaukee, Wis.*
**www.ritehite.com**

## Blast-resistant safety shelters protect workers and assets

This company offers a wide array of prefabricated buildings, mobile offices, trailers and storage solutions for construction jobsites. The modular Satellite Safety Shelters Blast Resistant Modules (BRM) are suitable for use in Zone 1, 2 and 3 petrochemical, petroleum-refining and other industrial applications, says the company. A variety of standard and customized configurations and sizes are available, to withstand pressures from 1 to 8 psi. The standard safety shelter is 12 by 40 ft, with an open floor plan that allows for flexible internal configuration. These tempo-

Note: For more information, circle the 3-digit number on p. 90, or use the website designation.

rary or permanent units can also be stacked when space limitations exist. They are PICS qualified and adhere to API RP 753 guidelines, says the company. — *Satellite Shelters, Inc., Plymouth, Minn.*
**www.satelliteco.com**

## Explosion-proof emergency LED illuminates the exits

The EXP-EMG-EXT-LE6-3L-V2 is a bug-eye LED exit sign and light fixture that is approved for use in C1D1/C2D1 locations. This explosion-proof device produces 99 lumens of illumination. The exit sign comes with either a left-pointing or right-pointing arrow to indicate the direction of the nearest exit. This device features self-testing and a backup emergency battery, which will ensure continuous operation for at least 90 minutes in the event of a power outage. It is ideal for use as emergency failsafe lighting in areas where explosion-proof fixtures are required, says the manufacturer. The entire assembly is made of powder-coated, die-cast aluminum with polycarbonate lenses protecting the LED bulbs, and operates on 120/277 V a.c. at 60 Hz. — *Larson Electronics LLC, Kemp, Tex.*
**www.larsonelectronics.com**

## Overfill protection for challenging applications


*Ametek Drexelbrook*

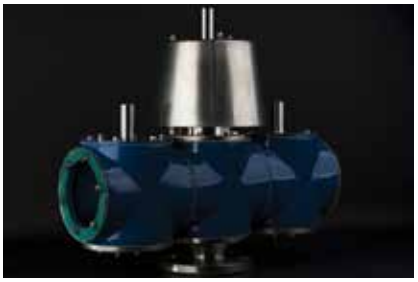
Designed for use in facilities that require safety-instrumented functionality (SIF), the SIL IntelliPoint RF Series point-level transmitter and safety switch (photo) is suitable for use in challenging environments that must meet API 2350 Overfill Protection Standards, says the company. It now has full SIL2 Certification (SIL3 when a redun dant switch is included). It is certified in accordance with IEC61509-2 and has worldwide hazardous area approvals (FM, FMc, ATEX and IECEX-pending). The device features state-of-the-art electronics and built-in Auto Verify circuitry that continually self-tests the complete system and alerts personnel if a fault is detected. No calibration or setpoint adjustments are required, according to the manufacturer. — *Ametek Drexelbrook, Horsham, Pa.*
**www.drexelbrook.com**

## This fire-resistant material is designed for offshore use


*Trelleborg AB*

The Firestop fire-resistant material (photo) is a rubber-based compound that can be molded or extruded into numerous shapes and helps to minimize fire escalation. It allows finished components to be thinner and lighter compared to those made from cur-

Fabrica Nazionale Cilindri S.p.A. (FNC)



Rembe, Inc.

InfraTec


Steute Industrial Controls

rent passive fire-protection materials. This makes it ideal for use in offshore oil-and-gas applications. — *Trelleborg AB, Stockholm, Sweden*
**www.trelleborg.com**

## Compact flame arresters are easy to disassemble

This latest generation of flame arresters (photo) includes a new, patented construction concept, according to the company. The deflagration-proof end-of-the-line type is available in sizes 1 in. through 16 in. An inline, bi-directional flame arrester provides deflagration protection, and is available in sizes 1 through 20 in. Meanwhile, a bi-directional flame arrester is also available to provide inline, stable and unstable detonation protection. All are available in a range of materials, including carbon steel, stainless steel and several other metals and coatings. They are designed for easy assembly and disassembly to ease maintenance efforts. — *Fabrica Nazionale Cilindri S.p.A. (FNC), Cislago, Italy*
**www.fncitalia.it**

## Head gear protects workers from extreme heat

Excessive heat exposure, indoors or outdoors, presents a dangerous on-the-job hazard for many chemical process industries (CPI) workers. The Chill-Its Cooling Products includes a large assortment of bandanas, hats, headbands, dew rags and towels, made from a high-performance, moisture-wicking, quick-drying fabric that promotes evaporative cooling and reduces the risk of heat stress. These head-covering items are comfortable to wear under hats, helmets or alone. Some have tie closures, others have a hook-and-loop closure. Colors include black (to hide dirt), high-visibility orange and a variety of patterns, including camouflage. — *Ergodyne, St. Paul, Minn.*
**www.ergodyne.com**

## Reduce explosion risk with this flameless explosion vent

Primarily designed for elevators and screeners, the Q-Ball (photo) uses the "contour parallel venting principle" to guarantee a flameless explosion-venting option for CPI process operators. It is designed to keep flames, pressure and dust from escaping the unit. Several recent advances help the Q-Ball to reduce the required vent area to a minimum while maximizing venting effectiveness, says the company. For instance, its weight has been reduced, thanks to engineering advances that have replaced outer frame profiles, says the manufacturer. It is available in four available sizes. Integrated signaling allows for easy monitoring. Recent innovation in the stainless-steel mesh material helps to cool down flames (up to 5,400°F) extremely efficiently within 500 milliseconds, which extinguishes the explosion, according to the company. — *Rembe, Inc., Charlotte, N.C.*
**www.rembe.us**

## Compact detector provides rapid flame detection

Ongoing advances in infrared detectors have allowed for the production of increasingly smaller, more-complex fire-fighting components. The new Pyromid LRM 244 detector (photo) is a pyroelectric detector that combines four channels in one housing (15.2 mm dia.). An aperture window of 8.5-by-8.5 $mm^2$ is integrated within the cap of the housing. The detector's large, symmetrical field of view (>90 deg) allows flames to be detected within the greatest possible angular range with an ideal signal-to-noise ratio, says the company. — *InfraTec GmbH, Dresden, Germany*
**www.infratec.de**

## Pull-wire safety switch initiates emergency stops

The Series ZS 71 emergency pull-wire switch (photo) is equipped with snap-action, NC-positive-break contacts, providing a safe, reliable means for initiating an emergency stop along the length of the installed pull wire. The switching function is actuated when the wire is pulled or broken. It has a 35-m reach, integral push-botton reset, die-cast aluminum and powder-coated housing. An IP 69K ingress-protection rating makes it suitable for a range of applications. It has an operating temperature range of –25°C to 70°C, and a mechanical life of more than 100,000 cycles. — *Steute Industrial Controls, Ridgefield, Conn.*
**www.SteuteXtreme.com**

## Vortex flowmeters are designed to enhance safety

The Rosemount 8800 Vortex flowmeters (photo) are now SIL 2/3-certified (per IEC 61508) and are suitable for safety-instrumented systems. They are designed to reduce process downtime and prevent spurious trips. A single Rosemount 8800 Vortex meter may be used up to SIL2, and the Dual Vortex meter may be used up to SIL3. It comes in a variety of configurations, supporting installations up to 12 in. (300 mm) line sizes, with flanged, wafer, reduced, dual and quad meter body styles. — *Emerson, St. Louis, Mo.*

**www.emerson.com**

## Industrial breakaway couplings reduce risk to assets, people

This company's compact, lightweight Flowbreak Breakaway Couplings are designed to activate in an emergency, to prevent the loss of fluid products (liquids and gases) during transfer operations. The device provides instantaneous closure of both upstream and downstream flow of liquid or gaseous media when activated. — *KLAW Products, Wiltshire, U.K.*

**www.klawproducts.com**

## Protect air quality in magnetic resonance imaging facilities

Safeguarding the quality of air inside magnetic resonance imaging (MRI) facilities is essential to protect the hospital staff and the MRI technology assets, as MRI systems use compressed (liquid) helium to cool superconductive magnets in the MRI scanners. There is a potential risk of helium being released, due to equipment malfunction, power outage or magnetic or vibrational disturbances. The ISA-60M oxygen-deficiency monitor (with MRI-5175 oxygen sensor transmitter) provides continuous surveillance and alarm capabilities to safeguard workers in these types of facilities. — *Enmet, Ann Arbor, Mich.*

**www.enmet.com**

*Suzanne Shelley*

*Emerson*

# New Products

Schenck Process

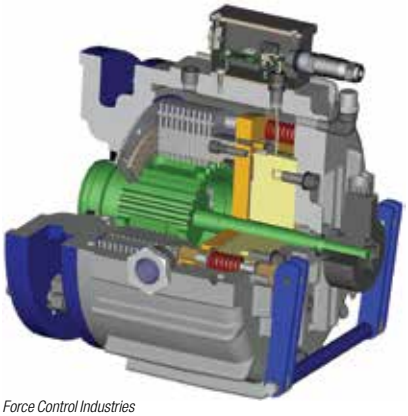
## Dense-phase conveying for fragile granules or pellets

The E-finity (photo) is a continuous, dense-phase conveying system for fragile materials. Precise pressure monitoring and airflow corrections allow the system to operate efficiently under a wide range of conditions, while gently inducing materials through the conveying line in slug form. E-finity is well-suited for granular and pelleted materials. The system's air controls can employ a single air source to operate two or three different systems simultaneously. The result is cost savings in both equipment and installation, says the company. — *Schenck Process LLC, Kansas City, Mo.*
**www.schenckprocess.com/us**

Emerson

## This oxygen analyzer is designed for smaller boilers

The Rosemount CX1100 in-situ oxygen analyzer (photo) is said to be the first high-performance, zirconia-cell-based combustion-control system designed to improve energy efficiency and meet environmental regulatory requirements for small and midsize boilers. It features the same sensor reliability found in large industrial technology, but the system is built to the requirements of boilers used in smaller applications. The zirconia sensing cell and the all-welded probe provide a long sensor life. The combustion-control system requires no reference gas, which keeps installation and maintenance costs low. — *Emerson, St. Louis, Mo.*
**www.emerson.com**



Force Control Industries

## These motor brakes avoid issues with wear and heat buildup

The MagnaShear motor brake (photo) employs oil shear technology that transmits torque between lubricated surfaces, thereby preventing wear on friction surfaces. A patented fluid-recirculation system dissipates heat, eliminating heat buildup, which is the most common problem in dry braking systems. Elimination of the wear increases service life and also elongates maintenance intervals. MagnaShear motor brakes are ideal for applications where the motor is reversed each cycle. Totally enclosed, MagnaShear brakes are impervious to moisture, dirt and dust, and can be sized to the correct torque independent of the motor frame size or horsepower. They have "quick mount" features for simplified mounting to drive motors in NEMA frame sizes 56 to 449. — *Force Control Industries, Inc., Fairfield, Ohio*
**www.forcecontrol.com**

Rockwell Automation

## A PLC that supports modular and user-defined functions

The new Allen-Bradley Micro 870 programmable logic controller (PLC; photo) can support applications that require up to 304 I/O points, 280 kB of memory and 20,000 program instructions. The Micro870 PLC uses a flexible design concept that provides designers up to three plug-ins and eight expansion I/O modules. This capability allows them to easily customize or expand the controller to meet each machine type's unique requirements. The controller's memory capacity supports modular programming and the use of user-defined function blocks to help reduce design time. Additionally, machine builders can use the memory capacity to maintain a single program for all machine models that use the Micro870 PLC. The controller communicates via EtherNet/IP and has multiple embedded communications options, including a USB programming port, a non-isolated serial port and an Ethernet port. — *Rockwell Automation, Milwaukee, Wis.*
**www.rockwell.com**

## Comprehensive density measurement for many chemicals

The CL 10HY-V2 density cell and Series 2000 density digital converter (photo, p. 37) can be used to measure the density of ammonium hydroxide, caustic soda, ethylene glycol, methanol, nitric acid, oleum, phosphoric acid, sodium chloride and sodium hydroxide. The CL10HY-V2 cell is double-sealed for protection against leaks and provides density measurement for high-pressure service up to 1,480 psig. It is available in a variety of corrosion-resistant metals and is explosion-proof. The Series 2000 converter has an onboard microcontroller and requires no programming from the user. The software provided with the converter calculates the gravity using

the density and temperature information generated by the CL10HY-V2. A two-line LCD screen displays the temperature, density, product frequency and status. — *Dynatrol, a division of Automation Products, Inc., Houston*
**www.dynatrolusa.com**

## Prevent bacterial growth in open-circuit wet cooling towers

This company's Sanipacking fills (photo) prevent the growth of bacteria and reduce the risk of *Legionella* bacteria in wet cooling towers with open circuits. Sanipacking fills also prevent colonization of the fill surface by the microbe *Pseudomonas aeruginosa*, the species most frequently found in the biofilm of industrial cooling water. To maintain the full antimicrobial effect for three to five years, it is necessary to keep the surfaces of the fills free of inorganic encrustation with effective water treatment and regular maintenance. The impact-resistant and pressure-stable Sanipacking fills consist of special individual polypropylene films that are systematically sealed together to form stable modules with a cross-fluted structure. In addition, high-efficiency NET150 splash fill packs are available with Sanipacking materials. The honeycomb-shaped modules can operate with effective resistance under water temperatures of up to 80°C. The material does not contain arsenic or heavy metals, and is resistant to fouling, fungal effects, corrosion and UV radiation. — *Enexio Management GmbH, Herne, Germany*
**www.enexio.com**

## Advanced low-maintenance rotary vane pumps

The new two-stage Sogevac NEO D rotary vane pump (photo) is equipped with a high-quality exhaust filter inside the oil casing. Built-in filtration reduces the required integration volume of the pump and ensures a cleaner environment without oil smoke or loss while pumping down. The acoustic properties also set new standards — the pump is said to be 3 dBA quieter than conventional models on the market. Sogevac NEO D is designed for maximum uptime through its new shaft-seal-

*Dynatrol*

*Enexio Management*

*Leybold*

Kason


Ashcroft

ing technology and the use of durable mineral oils. This results in maintenance-free operating intervals of up to three years. — *Leybold GmbH, Cologne, Germany*
**www.leybold.com**

## Gently grind challenging materials with this cone mill

The CGM 750 (photo) is a new cone mill with a diameter of 29.5 in. (750 mm) that gently grinds fatty, heat-sensitive, sticky, moist or fragile materials into uniform particle sizes with minimal fines at rates up to 32 metric tons/h. Vertical material flow and low-energy grinding action with short residence times yield close particle-size distributions from 125 to 250 µm, without the noise, dust, product buildup or heat generation associated with traditional mills, according to the manufacturer. The sanitary unit is suitable for wet and dry milling, pre-conditioning and de-agglomerating of a wide range of bulk products. A pneumatic, swing-down conical discharge chute with quick-release clamps allows easy lowering of the cone housing and full access to the housing interior, beater and perforated conical screen for cleaning and sanitizing. Provision is included for optional air purging of bearings and seals. — *Kason Corp., Millburn, N.J.*
**www.kason.com**

## A new all stainless-steel pressure gage

The new 1209 pressure gage (photo) is equipped with a 316L stainless-steel solid front case and ring, along with a pressure-relief back cover to ensure that the process fluid will be directed away from the operator in the event of an internal failure. Optional liquid fill or the patented Plus Performance option dampens shock, vibration and pulsation. With a 4.5-in. dial size and accuracy to ±0.50% of span, the 1209 pressure gage meets the requirements of ASME B40.100, Grade 2A standards for accuracy. The device can handle pressures up to 20,000 psi. — *Ashcroft Inc., Stratford, Conn.*
**www.ashcroft.com**

*Mary Page Bailey*

# Activated Sludge Process

*Department Editor: Scott Jenkins*

The activated sludge process (ASP) is designed to speed up the rate of decomposition of waste material in water. First developed in 1914, it remains an important means of treating both municipal and industrial wastewaters. This one-page reference provides information on the key process components and operating parameters of the ASP.

## Role of microbes and enzymes

The ASP involves the creation and management of a human-engineered and managed ecosystem of desired microbial populations that convert biodegradable organic substances in the wastewater inlet stream into $CO_2$ and new biomass. The term "activated sludge" refers to the particles produced in wastewater by the growth of organisms in aeration tanks. It differs from primary sludge in that the sludge particles contain many living organisms that feed on the incoming wastewater.

Activated sludge consists of a mixed community of microorganisms, 95% of which are a variety of (mostly aerobic) species of bacteria. Activated sludge also contains significant populations of fungi, protozoa and higher forms of invertebrates.

At the level of actual biodegradation reactions, two categories of enzymes are involved — namely extra- and intracellular enzymes. Extracellular enzymes are excreted at the cell surface by the microorganisms, and they help to break down the pollutants outside the cells into smaller metabolites that are small enough to permeate the cell walls. As the smaller fragments are transported into the cells, they are integrated into the microbe's metabolic process, where they are further oxidized to provide cellular energy, or are converted into new "building blocks" for cellular synthesis by intracellular enzymes.

## ASP process steps

In the ASP, activated sludge is added to wastewater, and the mixture is aerated and agitated. With sufficient food and oxygen, aerobic bacteria thrive in the aeration tank (see Figure).

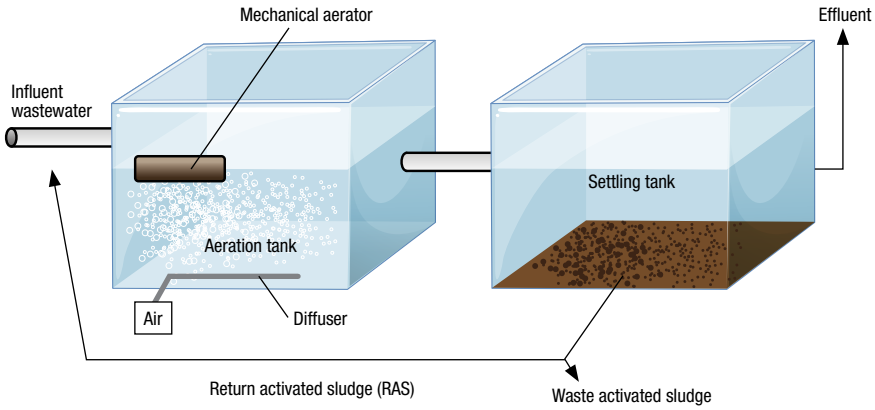



**FIGURE 1.** The diagram shows the basic processes found in activated sludge process (ASP) operations

Solids-retention time (SRT) is an important operational parameter that represents the average time spent by the sludge in the biodegradation basin. The SRT is controlled by the sludge-wasting rate.

As microorganisms grow, they form particles that clump together, and are allowed to settle to the bottom of a tank. The liquid above it is relatively free of organic material and suspended solids. When the waste reaches the end of the tank, the bacteria has used most of the organic matter to produce new cells.

After a certain period of time, the activated sludge is allowed to settle out by sedimentation, and is either disposed of (waste actived sludge) or returned to the aeration tank (return activated sludge). Flocculation refers to the process by which small, suspended particles bunch together into heavier particles (flocs) and settle out.

## Settling

For a classic ASP wastewater-treatment plant to work effectively, the sludge flocs need to have good settling properties. Good floc formation allows for an efficient solid-liquid separation to occur, after the sludge has removed the organic contaminants from the wastewater in the biodegradation basin. Efficient solid-liquid separation between the sludge and the treated wastewater is typically carried out using simple gravity settling in clarifiers to yield a solids-poor effluent stream.

## Aeration

Aeration is a key aspect of the ASP because it fulfills two critical functions. It supplies the oxygen needed for the microorganisms to grow, and also promotes optimum contact between the dissolved and suspended organic matter in the wastewater and the microorganisms.

Aeration can be performed mechanically or by using a diffuser system. Mechanical aerators physically splash the wastewater into the atmosphere above the tank to create turbulence. Mechanical aerators include brushes, blades or propellers that introduce air from the atmosphere into the wastewater. Surface aerators float at the surface or are mounted on supports in or above the basin. Mechanical aerators tend to incur lower installation and maintenance costs.

A diffused-air system introduces compressed air through a perforated membrane into the wastewater. Diffusers are classified by the physical characteristics of the equipment, or by the size of the air bubbles. ■

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# Propylene Oxide Production

*By Intratec Solutions*

Propylene oxide (PO) is a highly reactive commodity compound that serves as a starting material for several widely used products, from polymers and solvents to industrial fluids. Historically, PO has been produced by the so-called chlorohydrin process, which is further described in this article. Currently, new production technologies that generate less waste are starting to replace the chlorohydrin production process.

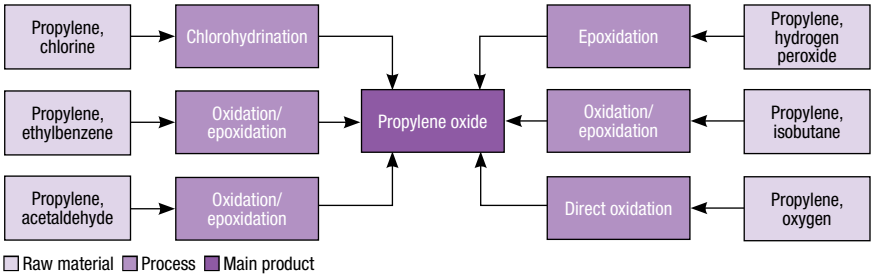



**FIGURE 2.** There are several production pathways to arrive at propylene oxide

## The process

The following describes a typical chlorohydrin process for PO production from propylene and chlorine (Figure 1).

***Hypochlorination.*** Initially, fresh, gaseous polymer-grade propylene and chlorine are mixed with water to form an aqueous solution. Such compounds react to produce a propene-chloronium complex, an intermediate that reacts with water to yield hydrochloric acid and propylene chlorohydrin (PCH) isomers. The gaseous effluent from the reactor is fed to a separator, which separates a solution containing PCH from the vent gas. The PCH solution is directed to the epoxidation stage, while the vent gas is passed through a caustic scrubber and released.

***Epoxidation.*** The PCH solution and a caustic solution (from a chlor-alkali unit) are fed to a saponifier, where a dehydrochlorination reaction takes place. Here, the PCH is converted to propylene oxide, while organic impurities are stripped from the brine.

The brine from the saponifier bottom is directed to a treatment step, while a stream containing PO from the saponifier overhead is routed to purification steps.

***Purification.*** The PO-rich stream is distilled in a first column to obtain a crude propylene oxide stream, which is removed from the column overhead. A solution containing dichloropropane (DCP) byproduct from the column bottom is decanted, yielding a DCP-rich stream and water. In a second column, residual light ends are stripped off from the crude PO stream and burned for fuel. The column's bottom product is fed to a third column, which further removes impurities from the PO. A 99.9 wt.% PO, withdrawn from column overhead, is condensed and routed to storage facilities. Heavy ends from the column bottom are burned for fuel.

The DCP-rich stream is treated with an acid-caustic-water wash, for the neutralization and removal of epoxidation byproducts, and then distilled for the removal of heavy components.

The brine stream from the epoxidation step and the wastewater from the first column are treated by biodegradation and filtration. The treated brine is returned to the chlor-alkali facility.

## Production pathways

There are two main routes for PO production — one based on the dehydrochlorination of propylene chlorohydrin with a base, and the other based on the oxidation of propylene by an organic hydroperoxide (Figure 2).

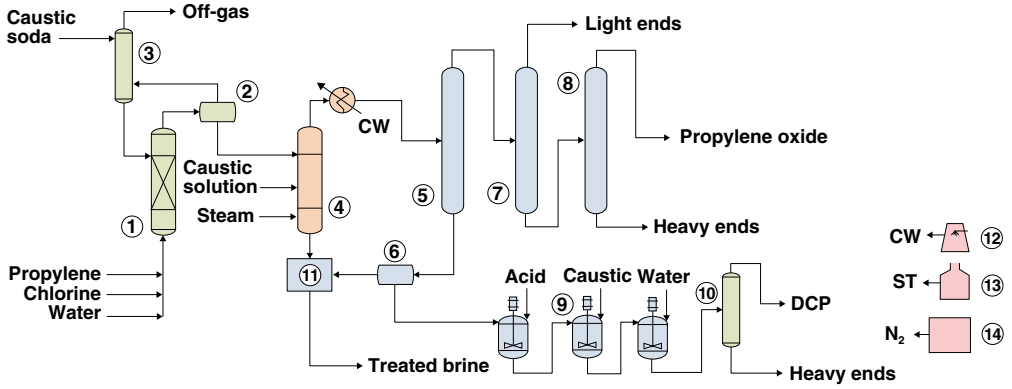
## Economic performance

The total operating cost (raw materials, utilities, fixed costs and depreciation costs) estimated to produce propylene oxide was about $2,360 per ton of propylene oxide in the second quarter of 2014. The analysis was based on a plant constructed in the U.S. with capacity to produce 500,000 metric ton per year of propylene oxide.

This column is based on "Propylene Oxide from Propylene and Chlorine – Cost Analysis," a report published by Intratec. It can be found at: www.intratec.us/analysis/propylene-oxide-e11a. ■

*Edited by Scott Jenkins*

**Editor's note:** The content for this column is supplied by Intratec Solutions LLC (Houston; www.intratec.us) and edited by *Chemical Engineering*. The analyses and models presented are prepared on the basis of publicly available and non-confidential information. The content represents the opinions of Intratec only. More information about the methodology for preparing analysis can be found, along with terms of use, at www.intratec.us/che.




1. Hypochlorination reactor
2. PO decanter
3. Caustic scrubber
4. Saponifier
5. Water removal column
6. DCP decanter
7. Light ends column
8. Heavy ends column
9. Acid/caustic/water washes
10. DCP column
11. Treatment unit
12. Cooling tower
13. Steam boiler
14. Air separation unit

CW Cooling water
ST Steam
N2 Nitrogen

**FIGURE 1.** The process diagram here shows the production of propylene oxide from propylene and chlorine

# Precision Grouting: Setting the Foundation for Equipment Reliability

A clear understanding of grout material properties is important to ensure that equipment is effectively protected against vibration and misalignment

**Christopher Adams**
BASF Corp.

## IN BRIEF



Reliability of critical rotating equipment depends first and foremost on maintaining precision alignment. This requires a robust foundation under the equipment that is designed to withstand the amplitude and frequency of vibrations that compound dynamic loads transferred to the base. The importance of grouting, both from a material properties and installation standpoint, is often overlooked during the design of foundations for rotating equipment in the chemical process industries (CPI). While most engineers recognize certain grout properties, such as compressive strength and creep, other important properties, including bond strength, bearing area and flowability, are not as commonly considered during the design process.

**FIGURE 1.** The aggregate component of a polymer grout acts as a heat sink to absorb the heat created by the exothermic reaction between the epoxy resin and the amine hardener

Supplier datasheets are now including data from ASTM International (West Conshohocken, Pa.; www.astm.org) and other information for cementitious and epoxy grout from organizations like the American Concrete Institute (ACI; Farmington Hills, Mich.; www.concrete.org) and the International Concrete Repair Institute (ICRI; Rosemont, Ill.; www.icri.org). Table 1 lists some relevant industry standards and guidelines related to grouting materials.

Despite the wealth of data available, it can be difficult to narrow down the most important parameters to consider. For instance, what characteristics are truly important for the reliability of critical rotating equipment in terms of damping vibration and maintaining alignment to extend the mean time between failures? This article explores and identifies the important grout properties necessary to reduce production downtime and repair costs associated with excessive vibration of machinery related to grout.

## Critical properties

Fundamental property examination of cementitious and epoxy grouts has traditionally focused on strength and the ability of a material to maintain that strength over an extensive period. Maintaining alignment and damping vibration is the best way to ensure longer mean time between failures for

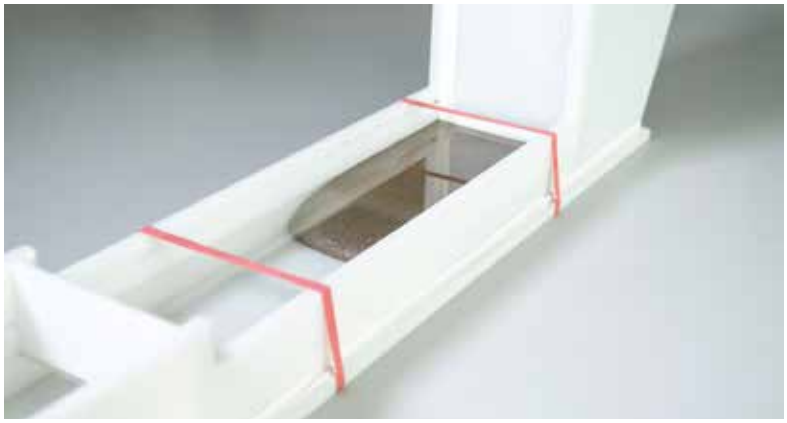


**FIGURE 2.** The flow box test, as defined in ASTM 1339, is used to examine the flowability of certain grouts

dynamic equipment. No equipment owner wants to deal with plastic deformation, cracking or voids in the grout layer under equipment. These problems lead to added reliability costs, as well as production downtime costs. Strength plays a major role in the resistance to plastic deformation, which in the case of grout, is the subsidence of a material from its original positioning. Compressive strength is a critical property that provides a criterion of quality grout and allows one to understand the general expectation of cure time.

Furthermore, maintaining strength over time while resisting plastic deformation due to stress, also known as creep, has been the best measurement to understand if a grouting material may subside from the underside of equipment due to compressive loading. Both compressive strength and creep measurements have long dominated the space of vendor datasheets with comparable testing from an ASTM standpoint [*1*]. Harder to find on datasheets is information about rheological properties, and specifically, the balance between flowability and compressive strength, especially for polymer grouts. A grout can have five times the compressive strength of concrete, but without being able to place via flowable means, what good is the high-strength grout material for stabilizing aligned equipment? If voids are present under the equipment, then there is, in effect, no strength at those points of absence. Like that of concrete, cementitious grouts flow better with higher water content, but this higher water presence adversely affects compressive strength and creep [*1*]. Likewise, epoxy grouts flow better with a higher resinous content, but also have similar compressive-strength reductions with increased fluid to aggregate components. There is a balance of properties when it comes to strength and placement, and one comes at the sacrifice of the other.

## Compressive strength versus flowability

Identifying the need for compressive-strength values depends on the expected live loads (unstable and transient) and dead loads (fixed and static). In the case of precision grout, these live and dead loads are due to the equipment being supported and any forces acting on that equipment. Examine one equipment owner's specifications and it may require 16,000 psi com-

**TABLE 1. SELECTED INDUSTRY GUIDELINES AND REFERENCES RELATED TO GROUTING MATERIALS**

| |
|---|
| ASTM C125 Standard Terminology Relating to Concrete and Concrete Aggregates |
| ASTM C1107 Standard Specification for Packaged Dry, Hydraulic Cement Grout (Nontrunk) |
| ASTM C940 Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced Aggregate Concrete in the Laboratory |
| ASTM C579 Standard Test Methods for Compressive Strength of Chemical Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes |
| ASTM C1437 Standard Test Method for Flow of Hydraulic Cement Mortar |
| ASTM C939 Standard Test Method for Flow of Grout for Preplaced Aggregate Concrete (Flow Cone Method) |
| ASTM C230 Standard Specification for Flow Table for Use in Tests of Hydraulic Cement |
| ASTM C1339 Standard Test Method for Flowability and Bearing Area of Chemical Resistant Polymer Machinery Grouts |
| ASTM C827 Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures |
| ASTM C1090 Standard Test Method for Measuring Changes in Height of Cylindrical Specimens of Hydraulic Cement Grout |
| ASTM C531 Standard Test Method for Linear Shrinkage & Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes |
| ASTM C580 Standard Test Method for Flexural Strength & Modulus of Elasticity of Chemical Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes |
| ASTM C469 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression |
| ASTM C1181 Standard Test Methods for Compressive Creep of Chemical Resistant Polymer Machinery Grouts |
| ASTM C512 Standard Test Method for Creep of Concrete in Compression |
| ASTM C33 Standard Specification for Concrete Aggregates |
| ACI Committee 351 Foundations for Equipment and Machinery |
| ACI 351.1R-12: Report on Grouting between Foundations and Bases for Support of Equipment and Machinery |
| ACI 351.2R-10: Report on Foundations for Static Equipment |
| ACI 351.3R-04: Foundations for Dynamic Equipment |
| ACI 351.4-14: Specification for Installation of Cementitious Grouting between Foundations and Equipment Bases |
| ACI 351.5-15: Specification for Installation of Epoxy Grouting between Foundations and Equipment Bases |
| ICRI Committee 320 Materials and Methods |
| ICRI 310.2 Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays (formerly No. 03732) |
| ICRI 320.5 Pictorial Atlas of Concrete Repair Material Mixing Equipment |
| API 686 Recommended Practice for Machinery Installation and Installation Design |

One method of fatigue testing is known as Det Norske Veritas (DNV-OS-C502), which examines a grout cylinder by cyclically loading the specimen at an established compressive value for a predetermined frequency — for instance, so many number of hertz per second. Repeating the cycle, a specific number of iterations will simulate the lifecycle of a piece of equipment and show deformation or failure expected from a grouting material over time. For an equipment owner, knowing the expected life of a grouting material under the operating conditions of the machinery is much more valuable for planning facility maintenance strategies than just knowing the material's compressive strength.

As for compressive strength, it can be evaluated on grout samples for specific cure temperatures, and in the case of cementitious materials, it can be provided in accordance with different consistencies. Consistencies for cementitious materials are standardized into categories for plastic, flowable and fluid, according to ASTM C1437. In installation, a plastic material will have higher compressive values during the curing step, but will be difficult to place under tight base-plate spaces of less than 1–2 in. in depth. An equipment owner sets the expectation for a material's compressive strength, but an installer may not be able to achieve that requirement with the material specified due to accessibility and the ambient temperature during installation.

eration of the rheological properties of cementitious and epoxy grouts. Grouts that are more flowable or fluid will have longer working times at a given temperature. Why is this important? For starters, a more efficiently poured material lowers labor costs, and more importantly, because the same material will act differently during the installation, depending on ambient temperature. For installers, flowability of a grouting material is paramount. In the case of epoxy or polymer grout, temperature and its effects on a grout's rheology are sticky to say the least, since the material is a viscous composition that resembles that of maple syrup. For epoxy grout, there is no addition of water to get a flowable consistency like that of cementitious materials.

**FIGURE 3.** The protocol for a flow box test involves the consolidation of grout into defined dimensions to measure its flow behavior

Polymer grouts are comprised of three components: epoxy resin, amine hardener and aggregate (Figure 1). The epoxy resin is typically a blend of monomers and oligomers and the hardener is a liquid with amine functionality [*2*]. As the two parts are mixed mechanically, the amine finds an oxirane ring in the epoxy resin to attack. This thermosetting resin creates a violent reaction during the oxirane ring opening, and the composition begins to very quickly undergo exothermic reaction. The third part, which is an aggregate blend, acts as a heat sink and absorbs much of the heat created by the reaction of the epoxy resin and hardener. This reaction can be further accelerated by higher ambient temperature. High temperatures will, in effect, lower the viscosity of the polymer material and allow for better flowability. If the reaction is accelerated too much, the material can become stressed and brittle, leading to post-cure cracking.

When installing polymer grouts, a good practice is to use expansion joints to break up the pour size. Expansion joints can minimize the impact of stresses created from the linear coefficient of thermal expansion between material interfaces and exothermic temperatures. Partitioning the grout into sections that are less

than 20 $ft^3$ in size using expansion joints will typically result in a grout layer that is free of cracking. Furthermore, consideration of installing a polymer grout during a day with 90°F temperatures will lead to lower working time and a higher peak exotherm, resulting in possible stress-induced cracking. The same material may require double the working time in a 65–70°F environment.

## Testing methods

Testing of flowability is available for those involved in the specification and installation of grouts. For cementitious materials, ASTM C939 details a flow cone test that measures the time for an established unit of fluid grout to pass through a funnel's orifice. To be considered fluid, the material in a specified volume must pass through the flow cone in less than 30 seconds. A test to measure flow for polymer grout is the flow box test described in ASTM 1339. The flow box test for epoxy grouts is the best standardized way to examine the flowable nature of polymer grout. The test consists of a box with a hopper on one end that constricts to an annular space of either 1 or 2 in. to simulate the condition of a base plate (Figure 2). The base plate, in the case of a flow box, is a polycarbonate plate that allows for viewing of the annular space. The mixed polymer grout is added to the hopper in an 11-in. depth for a 2-in. annular clearance, or an 8-in. depth for a 1-in. clearance, respectively [*3*]. The grout remains in the hopper during a consolidation period of five minutes. At the five-minute mark, a gate is lifted that separates the hopper from the annular space and the grout can flow (Figure 3).

Simultaneously, a timer is started and the grout proceeds to the back of the box. While the grout is flowing in the annular space, there is a viewing period before it comes into full contact with the polycarbonate plate, as well as a time before it contacts the back of the box. These times of contacting the plate and reaching the back of the box, known as the fill time and flow time, respectively, can be used to compare grout products from model to model and manufacturer to manufacturer. Not all materials are created equally, even if they have the same strengths. Consideration should be made for a grout's ability to be placed at a suitable yield level to ensure efficiency in the field. However, when aggregate is withheld to ensure flowability, all of the physical properties of the grout, besides the rheology, are reduced and the yield per unit is essentially lower. In some applications, the loss of strength in terms of bond and compression by aggregate reduction is

**FIGURE 4.** Pockets and voids in polymer grouts can cause problems, including uneven load distribution and ineffective vibration damping

acceptable, but this decision should be made by the engineer of record.

Another important takeaway from a flow box test is the capability to examine the bearing surface. When a fluid grout flows under a base plate, we assume contact with the bottom side of the plate if the grout fills the fluid volume of the annular space and proceeds to the back of the form. However, as a polymer grout flows under a plate, drag and friction, as well as entrained air from mixing, form pockets and voids under the base plate (Figure 4). These pockets and voids are problematic.

*Requiring more compressive strength than is necessary from a grout may come at the cost of other important requirements, including rheology, effective bearing area, and, in turn, the effective bond between the base plate and grout material*

For example, if the grout only contacts the underside at a rate of 70% effective bearing, then the load being distributed is only as uniform as the bearing surface; therefore, compressive loads are dispersed at higher concentrations for the areas that are in contact with the plate. Having a bond to the bottom of the baseplate is a benefit to epoxy grouts and locks a skid or baseplate into place. This "locking" effect, coupled with the lower modulus of elasticity of epoxy grouts, tends to dampen the magnitude of vibration better than cementitious grouts. Having only 70% effective bearing area due to poration and voids will reduce the bond-strength availability. Poration present on the top surface of the epoxy grout layer that comes into contact with the base or skid plate can also be a delamination concern. If a pocket of separation from the base plate occurs in the grout layer, or equipment coating separates from the plate, the grout will not dampen the magnitude of vibration as effectively [*4*].

Any number or depth of voids will adversely affect the available distribution of load. Selection of a grouting material with a high effective bearing area will more likely ensure bonding, and will allow for the manufacturer's reported grout tensile strength to be more in line with the actual field conditions. Careful consideration of a coating system and application thickness should be conducted prior to grouting to avoid bonding issues.

A specifier of grouting materials should be aware of the balance of properties that exists between compressive strength and rheology. Requiring more compressive strength than is necessary from a grout may come at the cost of other important requirements, including rheology, effective bearing area, and, in turn, the effective bond between the base plate and grout material. Mechanical reliability should not be sacrificed because a material is lacking the properties to be installed correctly. With rotor-stator and peristaltic pumps replacing traditional techniques of using head boxes to install grouts, mechanical tolerances are requiring lower-viscosity materials. The practice of pumping grouts is allowing for safer and more efficient installations, resulting in lower labor costs. Due to all of these considerations, it is critically important to select a precision grout with placeability in mind. ■

*Edited by Mary Page Bailey*

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Part 2

# Torque Limiter Technologies for Rotating Machinery

Torque overloads can cause serious problems for rotating machinery, but an understanding of torque limiting technologies can help engineers to enable more reliable operations

**Todd Lehman**
Voith Turbo

## IN BRIEF



Reliability, safety and productivity are key terms that come to mind when considering manufacturing plant operations. In the chemical process industries (CPI), there are difficult applications, such as those using continuous mixers and melt pumps, that operate with the risk of torque overloads. Overloads pose a threat to operational safety and can cause catastrophic machine failures. For example, failures caused by unexpected machine jams and electrical-grid-induced motor torque spikes can be severe enough to impact a chemical plant's production for days, potentially stretching into months. A rotating machine whose drive-chain design does not fully account for torque spikes caused by sudden machine jams or electrical-supply faults will expose the weak link, either during the occurrence of the torque spike or sometime later when the fatigued link finally breaks unexpectedly.

There are several ways to protect a drive chain. One method is to purposefully design the drive chain with a weak link, such as a closely sized flexible-connection coupling. Some level of perceived protection may be achieved through this method, but it must be considered that a failed flexible-connection coupling will require some degree of parts replacement and could cause damage to the surrounding drive components and guards, as well as requiring added downtime, parts and labor. The idea of a weak link in the drive chain is a good one, but that weak link needs to provide torque accuracy to maximize machine productivity, be easy to reset and not require a lot of parts or manpower. One approach to address the problem of maximizing machine productivity without exceeding machine capacity is the use of a torque limiter. There are many types of equipment within a CPI facility where increased reliability, safety and productivity can be realized from the application of torque limiting technologies. These include steam and gas turbine drives, compressors, expanders, centrifuges, fans, reactors, crushers, mixers, mills and pumps.

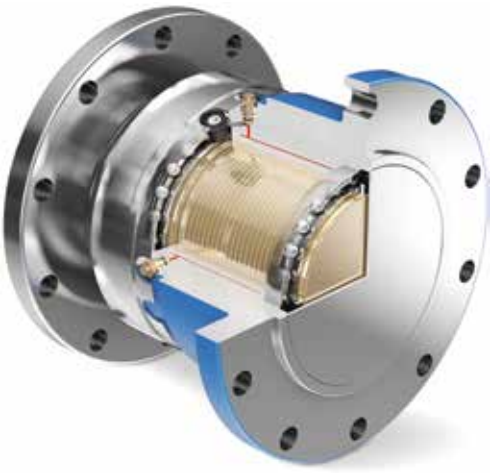

**FIGURE 1.** Hydraulically pressurized, friction-based torque-limiting couplings consist of a twin-walled hollow sleeve that can be pressurized

## Torque limiting technologies

Torque limiters are commonly used in stationary and mobile applications. They can be applied to equipment requiring less than 1,000 Nm and more than 15,000,000 Nm of torque, and operate at speeds from 1 to 10,000 rpm or more. Some limiter configurations are summarized in the following sections.

***Shear pin couplings.*** Shear pin couplings are fatigue-based limiters that use specifically sized pins to transmit a set amount of torque and require replacement after an overload or after they have experienced too much fatigue. Adjustment of the torque limiter capacity requires resizing of the shear pins.

***Ball-in detent couplings.*** These are spring-loaded limiters that can be reset through counter-rotation of the mounted parts or by re-engagement of the balls via taps of a mallet. Over a period of time, the detents wear

and the spring's tension decreases. Adjustment of the torque limiter capacity can typically be done through adjustment of the springs that apply pressure to the balls.

***Pneumatically pressurized, dry-running friction clutches.*** This type of clutch uses a clutch pack, which is a stack of clutch discs and steel discs. The clutch is engaged using an air bladder that is fed plant air, either axially through a drilled machine shaft or radially via a non-rotating portion of the friction clutch assembly. The torque-transmission capability of the clutch can be regulated by the applied air pressure. However, the torque-transmission capacity will decrease with any air leaks that occur, causing the clutch to slip and potentially overheat during normal machine operation. To avoid overheating the clutch in any operating scenario, the clutch must be monitored for extended periods of slip in order to avoid overheating and the potential for clutch failure.

***Hydraulically pressurized, friction-based couplings.*** These couplings (Figure 1) are backlash-free torque limiters that utilize shear tubes and a shear ring for release of the hydraulic pressure during a torque overload event. As soon as the pressure is released, the coupling freely spins without contacting the friction surfaces. The shear tubes are replaced and hydraulic pressure is re-applied based on the desired torque limitation to re-engage the unit. Adjustment of the torque limiter capacity can be accomplished by referencing a pressure-versus-torque calibration diagram that is typically supplied with a unit.

Mounting configurations of the previously mentioned torque-limiter types include, but are not limited to, a drop-out spacer design, a shaft-mount design that would replace the solid hub of a connection coupling and a design for integration with the flexible hub of a connection coupling. Some designs allow for integration within gearboxes or machine components.

## Torque limiter operation and setup

Having addressed the issue of safely maintaining machine reliability and production without exceeding design capacity, the next issue often occurs after the release of the torque limiter. It is true that the torque limiter has done its job to protect the drive chain of the machine by releasing, but it does not automatically reset to allow for a machine start. The requirement to physically reset the torque limiter is not necessarily bad, since it forces the operator to try to identify and understand the cause of the torque event that caused the release of the torque limiter. However, in some cases, the cause of the torque event may be readily known through instrumentation feedback in the control room. The torque limiter will still need some field attention to allow the machine to resume operation. This leads to the

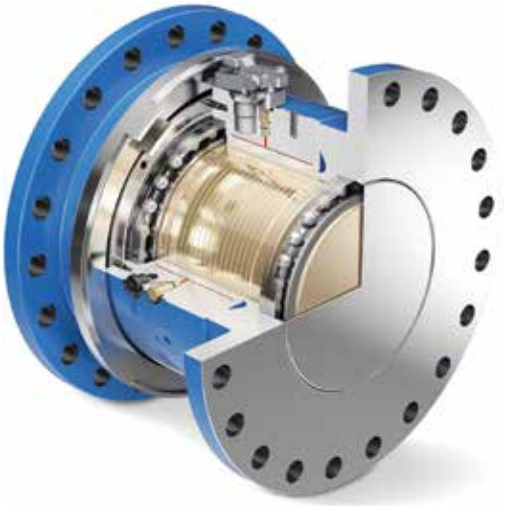

**FIGURE 2.** Friction plays an important role in ensuring the precision of hydraulically pressurized slipping torque limiters

first question — is there a way to limit torque but not release? A second question would follow — is there a way to limit torque and release only in situations of long-duration torque overloads?

The answer to those questions will depend on the application and the characteristics of the overload. A potential solution is offered by the ability to slip instead of fully release during short-duration overloads. Rather than immediately releasing on overload, some torque limiters can either slip for a number of degrees before releasing, or never release at all unless an external trigger is used or the machine-monitoring controls force a shutdown. These torque limiters are based on the hydraulically pressurized, friction-based design, but use specially selected friction surfaces to allow for extended periods of slip. To help understand these limiters, it is important to know more about their construction.

A basic torque-limiting coupling of this type is made up of an inner and outer sleeve that are assembled and welded at the ends. This assembly forms a twin-walled hollow sleeve that can be oil-pressurized after the machining of the necessary pressurization and shear-tube ports have been completed. The design of the shear tube and mating seat provides a sealed system, while the size of the torque-limiting coupling determines the size and quantity of shear tubes that are to be used. The friction surface is treated to prevent wear during the slip phase of the coupling release. Once the coupling has released, it rotates on bearings, preventing wear on the torque-transmitting friction surfaces.

During normal operation, the bearings of the torque limiter remain static. The bearings only rotate following a release due to torque overload, which makes bearing life a minor factor when considering the operational dependability of the coupling. The bearings and friction surfaces are separated from the pressurized sleeve and require lubrication oil. The lubrication oil is used for two things: bearing lubrication during a release condition, and to maintain a predictable friction coefficient across the friction surfaces, which results in a precise-release torque relative to the applied pressure.

As noted, hydraulically pressurized, fric-

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tion-based torque limiting couplings have no backlash and are not subject to material fatigue because the torque is transmitted through a friction surface. The applied hydraulic pressure generates a defined frictional force between the pressure sleeve and the shaft. The applied pressure determines the release torque of the coupling. Therefore, an increase or decrease of applied pressure, working within the torque limiters' adjustment range, will result in an increase or decrease of the release torque.

If the operating torque exceeds the pressure-based-release torque setting, the driving shaft will rotate relative to the pressure sleeve that is connected to the driven load. This results in an immediate reduction in applied torque when the friction force changes state from static to dynamic. The shear ring that is fixed to the driving shaft rotates relative to the pressure sleeve and breaks off the top of the shear tubes. Upon contact, the oil pressure in the coupling drops, and the applied frictional force in the coupling is reduced, releasing the torque limiting coupling and providing full separation of the driving and driven components of the drive chain.

Following a release, the coupling must be reset. First, the shear ring is aligned to allow removal of the shear tubes. Next, the shear tubes are replaced and torqued to specification. Finally, the coupling is re-pressurized according to the calibration curve of the unit.

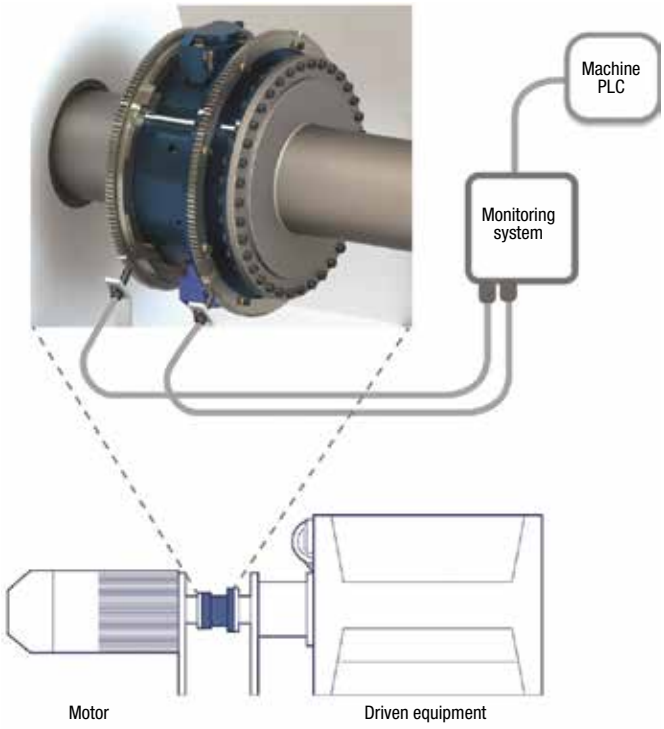


**FIGURE 3.** The data from torque limiters can be fed into a monitor system and used in the machinery PLC to avoid undesirable events, such as an incorrectly timed trip

## Advances in torque limiters

With the basics of torque-limiting couplings in mind, it is also important to understand the more advanced versions of these technologies, including: slipping torque-limiting couplings that have the ability to slip and eventually release to prevent damage from excessive slip due to machine overloads; and permanently slipping torque-limiting couplings that can only be influenced through external monitoring.

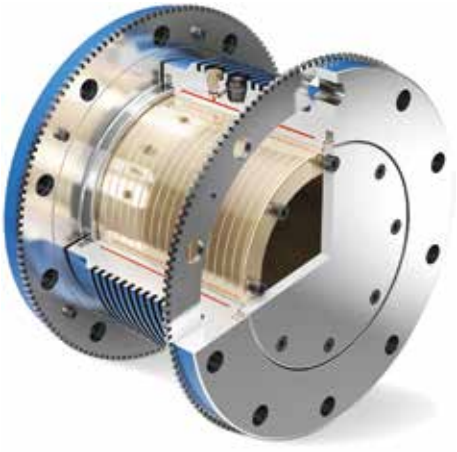

**FIGURE 4.** Slip-enabled couplings require no resetting, but should be used in conjunction with active monitoring devices

A hydraulically pressurized, friction-based, slipping torque limiter (Figure 2) is a mechanical-fault ride-through coupling (meaning it stays connected during periods of instability) that slips to trim or shave off torque peaks caused by short-duration overloads to protect the drive-chain components. This type of torque limiter was originally designed as a startup coupling for synchronous motor-driven centrifugal pumps and compressors. Synchronous motors generate high-amplitude, short-duration transient torques during acceleration and prior to grid synchronization. The slipping torque-limiting coupling can also fully release in situations of extended overtorques to protect the links of the drive chain, as well as the coupling itself. The technology and construction are based on the previously discussed design of the basic hydraulically pressurized, friction-based torque limiting coupling. However, there are differences that set the slipping torque-limiting coupling apart, as follows:

- It has the ability to slip in short durations without seizing due to its friction surface
- The slipping limiter device is centrifugally engaged by the shaft rotation of the application
- The slipping limiter design allows for a minimum slip before release of 30 deg and a maximum of 120 deg per start

The slip angle before release can be reset with each shutdown of the machine. This means that multiple short-duration torque events that cause the torque limiter to slip can be reset with a simple stop and restart of the machine, thereby providing the full 30- to 120-deg slip angle once more. With this type of torque limiter, the need for a machine shutdown is limited to instances of sustained short-duration overloads or a continuous overload. After a trip, the slipping torque limiter must be reset and re-pressurized for the appropriate torque. Furthermore, trips can be limited or avoided altogether with the use of an active slip monitor. The monitoring system can be used to provide feedback to the machine's programmable logic controller (PLC) to either stop the process or reduce the load before the torque-limiting coupling is mechanically forced to trip (Figure 3).

Another type of slipping torque-limiting coupling provides mechanical-fault ride-through capability to slip and trim or shave off torque peaks caused by short- or extended-duration overloads to protect the drive-chain components. This type of slip-enabled coupling (Figure 4) will not release. Therefore, no resetting of the coupling is required. Once more, active monitoring of the slip is important to provide a window into what is happening with the drive chain. While the coupling is designed to slip, it is not designed for permanent slip. Slip creates heat and is an indicator that the machine is being pushed past its design parameters. The monitor can "look" at the torque-limiter slip and can provide the machine PLC with feedback to make appropriate decisions, such as feed reduction, feed stop or machine shutdown.

Reliability, safety and production demands on chemical plant operators and machines continue to increase as companies focus intently on operating efficiency and controlled costs. As outlined, these demands require a hard look at machinery to consider what can be done to maximize capacities without sacrificing the ability to operate safely and reliably. Torque limiting technology is designed to help maximize a machine's productivity without exceeding design capacity or jeopardizing safety and reliability. ■

*Edited by Mary Page Bailey*

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# The Unrecognized Problems of Relocating Laboratories

## Follow the guidance provided here to avoid many of the problems that can arise during the relocation of laboratory facilities

**Richard Palluzi**
Richard P Palluzi LLC

The decision to move a laboratory from an existing space to a new research facility is often warranted. A merger or acquisition may require the transfer of some laboratory work, an aging facility may no longer be economically viable, downsizing or reorganization may call for consolidations or relocations, and numerous other business drivers may suggest or force a relocation. This can create an exciting time, as personnel see an opportunity to start over in a brand new setting, free of the persistent problems and issues they know so well in their old laboratory settings.

However, very few organizations realize how difficult a task it is to relocate an entire laboratory facility. Most research groups will never experience a major relocation so they rarely go through the process, and thus, their base of experience is little to none. Groups that have experienced a major laboratory relocation are normally so traumatized that they rarely analyze the overall relocation process closely — concentrating instead on fixing the problems, moving past them quickly, and hopefully forgetting them as soon as possible. Unfortunately, the problems resulting from a poorly planned relocation are often glossed over (and in some cases hidden) as company managers try to avoid the inevitable fallout (Figure 1). Certainly, the mistakes or deficiencies related to poor planning or execution are rarely shared with colleagues or competitors.

**FIGURE 1.** One example of a last-minute contractor change that had significant adverse impacts was the replacement of a small strut support (1-5/8 in.) by a 4-in. tubular support frame. This prevented easy modifications to allow deeper laboratory equipment to fit on many benches

### Myths that hinder the process

This author has participated in more than 15 laboratory relocations, new facility set ups, and studies over his career. Discussed below are a variety of observations and recommendations related to some of the major problems that are frequently encountered, and some of the prevailing myths that stand in the way of a successful laboratory-relocation project.

***Having an unrealistic schedule.*** When they fail to fully understand the complexity of the relocation process, stakeholders often develop a schedule that is geared toward meeting management's desires, or that is based on an overly optimistic view of the work required. This almost always ensures major project problems later, as too little funding is appropriated for the study, and insufficient time is allowed to evaluate realistic options or address problems. Too often, the study results represent little more than inspired guesswork that reflects wishful thinking related to desired outcomes, rather than a sound basis using hard information to reach a truly informed decision.

Organizations tend to produce studies that support their biases when there has not been adequate analysis. For instance, when they think a new laboratory site can be developed at a low cost, their natural inclination is to look most closely at what seem to be low-cost options — often without taking the time and effort needed to recognize that the options being considered may not address their needs completely, or may not be based on realistic estimates. And the more these unrealistic options are presented, the more difficult it is to shed the so-called rose-colored glasses to bring the harsher reality to the attention of company management.

Such bias, as well as the resultant less extensive analysis, can lead to bad decisionmaking and a failure to really understand the full impact of

**FIGURE 2.** A failure to carefully review preliminary drawings and confirm large equipment dimensions resulted in having to move large ducts by significant amounts in this laboratory's process bay

the proposed plan. A lower-cost option may be chosen, but it does not necessarily meet the organization's true needs, and may in the long run require significantly more funding or time to correct issues that surface later. Once the organization is committed to a relocation, it is virtually impossible to do anything except keep pouring in money and time into it until it is completed. This could have been avoided by taking the time and effort to really get an appropriate and realistic option evaluation, and to appropriately estimate, schedule and analyze the issues up front. It has been shown again and again that when sufficient time and effort is taken earlier in a lab-relocation project, overall project execution will be faster and cheaper, and fewer errors will be made that must be rectified later.

Assuming that the organization knows exactly what it needs. Few organizations really know everything that they need (or even a good part of it). They know what they have, what they'd like, and what their current problems are, but they have never really analyzed what they need to try to address these needs from the ground up. Many also tend to have only hazy (at best) ideas of what their future work entails. It's not that they can't figure out their needs; it's that they are not given the time, resources or help to do so appropriately (Figure 2).

For example, "We need more exhaust capacity" seems to be a perfectly logical demand for an organization that is short of hoods and is struggling to pass its annual hood-certification requirements. The right answer, however, may be that they need a better supply-air system to prevent starving their laboratories and making their hoods fail their mandatory annual testing, or a better understanding of what should and should not be in a hood to alleviate needless overcrowding. Conveying their needs to the contractor or design firm is equally difficult. For instance, indicating that you need a lower bench height to work on equipment may result in a 30–in. versus 36–in. height when 12 in. was needed or vice versa.

Another scenario is when the desire for increased flexibility results in spending on expensive mobile casework only to realize after relocation that the chosen solution is not stable (vibration-free) enough for your instrumentation.

**FIGURE 3.** Even a single instrument often requires significant utilities to be relocated and replaced. Sufficient time and effort should be allotted to properly document and tag each component prior to the move

Many laboratory-design firms showcase their ability to define the client's needs as a key selling point for their services. Unfortunately, I have seen few that are consistently good at this. Most either view their client's needs through their own perspective (often resulting in an unrecognized, subtle, but often significant shift in requirements), or they become focused on simply delineating exactly what the client has now and believes they want later, in minute detail (thus losing the bigger picture or the opportunity to consider other options).

Assuming that the laboratory owner's own personnel can simply move their own equipment with some limited specialist help (riggers, equipment manufacturers, and so on), I don't argue that this is not possible in theory; I do argue that this is impossible in practice. Normal operating personnel are too few and too specialized to relocate equipment effectively.

This author has seen organizations decide to simply move some laboratories across a street or within the building and rely on the existing operating personnel. This leads to excessive downtime and poor results, because the operating personnel don't have access to the right equipment, they are neither trained nor equipped for all the minor modifications the new location will require, and no one has really evaluated the full impact of the new space. Not surprisingly, it is common that almost immediately, operating personnel (if not their management) will quickly note that their new space seems to have many of the same problems as their old space.

***Having an unrealistic cost estimate and schedule.*** These two go hand in hand — if the work is underestimated, so is the cost and the time required. In many cases, estimates are prepared by contractors who have little (if any) idea of what is actually required. For example, plant personnel may tour an existing laboratory and see an oven with 5-ft, 2-in. duct, so they estimate it will cost $25 in materials and $100 in labor to install. In reality, the duct is designed to sweep the oven interior at six full air changes per hour. It needs to be larger than 2 in. in the new location. (It may have needed to be larger in the old system but was not recognized there as being inadequate). It requires an automatic damper to actuate. The ductwork and associated exhaust may not exist (although it was supposed to), or it may be buried in the ceiling and missed. Ultimately, the cost and effort to provide the right installation when the mistake is realized will be much higher than expected.

The sum of all these errors and omissions is enormous. In this author's experience, when asked to check a contractor's estimate, they were often found to be low, in both cost and time, by factors of 2–4. The result, if not recognized, of such poor estimating and planning will be severe cost and schedule overruns and ultimately shortcuts taken that lead to lower-quality outcomes.

***Failing to review current practices and procedures to determine if they really do meet the needs for which they were originally designed.*** Moving to a new laboratory gives an organization a narrow window to revisit all current operating and design practices and update them to their current and (as best as possible) envisioned future needs. Few contractors are capable of assisting in this effort very effectively. Few organizations take the time and effort to evaluate using this framework — if they were starting from a clean sheet of paper, would they really do it the way they are doing it now? However, the potential for truly significant savings and increases in productivity and effectiveness arises from this willingness to look critically at the approach being taken from the ground up.

***Having an unrealistic scoping cost for the new or modified facilities.*** It is common for the developer or real estate firm to develop scoping estimates based on typical dollar per square foot costs. There is nothing inherently wrong with this approach as long as the costs are for similar research-style facilities. However, they rarely are. The developer asks what it will cost to provide a 50,000-$ft^3$/min heating, ventilation and air conditioning (HVAC) system. A local design firm assumes it is going to cost the same as it would in an office building setting and gives a typical cost. When the detailed design is performed, the system cost turns out to be 5–10 times higher than what was estimated. This cost increase arises because no one recognized the need for corrosion-resistant ductwork, 100% once-through air, dehumidification and reheat, and a matching supply-air system that is 5–10 times larger than expected. In the worst-case scenario, the system gets built "for an office building" and is incapable of functioning properly as a research facility, leading to costly and time-consuming upgrades later. Even in cases when the "disconnect" between actual performance and the expected cost basis is realized early enough in the process, this mismatch often still leads to suboptimal decisions; other, more suit-

able but apparently higher-cost options may have been discarded, perhaps because they appeared to be more expensive than the contractor's "low-ball" estimate.

Once the full design work is done, these discarded options suddenly are realized as having been a better solution, but it is too late in the design process. Stopping the relocation progress and back-tracking to previously eliminated options is an action that rarely can be accepted even by the best organizations. Once committed, the momentum to keep going forward on the chosen path is almost irresistible.

***Failing to recognize (and hence account for) the cost and time for upgrades, repairs and corrective actions to existing equipment.*** No matter how firm the management edict, some equipment will need to be upgraded (or even replaced), as it is impossible to realistically relocate some equipment components. While identifying replacement equipment should be easy, it often takes more time and effort than is allotted for the study. Worse, some equipment will be found to be in need of repair or corrective action after further review (This author has often found this out, to his horror, only in the midst of disconnecting the equipment, which was to have been shipped "as is").

The disconnect that is blocked (in violation of code) will need to be moved, the gas system that is piped unsafely will need to be corrected, the furnace whose wiring shows signs of arcing when opened will need repair and so on. If you think that your organization is "too safety and maintenance conscious" for this to be significant, think again. These types of situations arise frequently — even in the best organizations.

***Failing to fully understand the new facility and recognize where changes to existing systems need to be made.*** A sudden realization that the chilled-water return has a 5-psig backpressure could require a pump and tank on each installation. A failure to understand how the new HVAC system is designed to work could result in having to rewire all the low-ventilation alarms. Less obvious, but often more problematic, is the sudden post-move recognition that the organization has limited effective ways to prevent the wrong materials from being put down a drain in violation of the new location's permits, or a sudden realization that the new materials-handling system does not really save the two full-time persons envisioned.

***Assuming waste streams and emissions that are acceptable in the current location will be so in the new facility, or that needed changes can be easily accommodated.*** Regulations may have changed, older facilities may be grandfathered, new data may indicate that there was an unrecognized existing problem, and similar issues can arise. In many cases, older facilities may have only the haziest idea of their waste streams (for example, if it is shared with the plant), and may have no realistic way to measure them. Often, operators are forced to "guesstimate" the amounts with attendant risk of over- or underestimating. This can result in significant delays and costs to obtain new permits or design-appropriate treatment systems.

***Not understanding all the intricacies of older systems and equipment that have worked satisfactorily for years.*** This author has often replicated existing systems

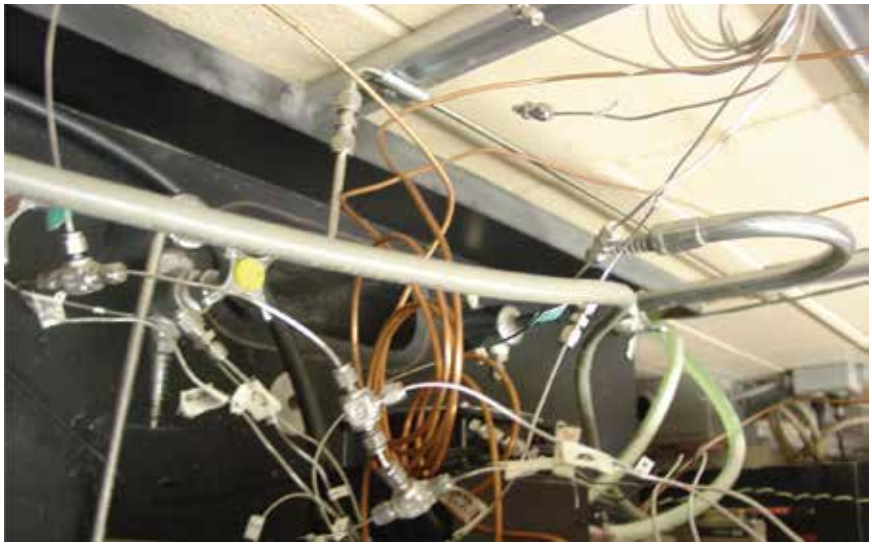


**FIGURE 4.** Tracing something like this takes time. It also suggests that the new installation should be more carefully planned and labeled for improved future outcomes

in a new location, only to encounter unexpected problems. This is usually due to changes made to improve, upgrade or lower the cost of the system. The problems that surfaced were addressed by the older systems but no one remembered about them until they arose again. Institutional memory can be remarkably short. Detailed documentation of existing systems, particularly with regard to why they were designed a given way, is very rare (The prevailing sentiment at the time is often "everyone recognizes the issue, so why should we bother to document it?").

This author has also encountered systems that worked well where they were, because of some unique local features — but then the system could not be economically replicated in the new location. If recognized in advance, a solution (even if it is costly and time consuming) can be explored. However, if such issues are only recognized during or after the relocation, the impact on timeline and budget will be even greater.

***Failing to assess the true impact of relocation on staffing.*** Some experienced personnel will decide not to relocate. Others will relocate but not be happy in the new location and may suddenly leave. If enough personnel have to be replaced, the resulting burden to find and train new personnel can create unexpected extra effort for an organization that is always overloaded — at least in the short term — during a relocation.

And this problem is not limited to only technical professionals. A sudden drop in the collective experience and institutional knowledge of the operating personnel, maintenance staff and support staff may suddenly force an organization to recognize how invaluable these people were and struggle to replace them. Through many projects, this author has seen the organization show unwarranted confidence in their technical staff — not recognizing that the old operating staff will not function as seamlessly if everything changes and the replacement operating staff is not yet knowledgeable enough to support them effectively.

***Assuming that existing information is accurate and adequately up-to-date.*** Whether it is process and instrument diagrams (P&IDs), layouts, operating instructions, or procedures, most of these essential documents are never truly up-to-date. Operating procedures will call for annual reviews. Reports will indicate almost complete compliance. Organizations will feel confident. All will turn out to be unfounded.

Equipment to be relocated must have completely up-to-date and accurate documentation available, with sufficient time and effort allotted to develop the needed documentation built into the project. For instance, the effort to trace out all the piping and wiring, to read and cross-check all the operating instructions and procedures is significant and usually consumes all of the operating personnel's time, leaving little to support

the actual relocation or even sometimes the planning (Figure 3).

What can you do to deal with these problems? Clearly, the recommendation to simply not relocate to a new facility is not always an option. You must take care during the planning and execution of the laboratory relocation, to help maximize the chance for success.

## Mitigating measures

Some proven strategies and best practices are discussed below.

***Make sure that the scoping estimates that are used for decision-making are accurate and realistic enough to make an informed decision.*** This is likely to take more time and cost more than desired. Speed can be accommodated, to some degree, by larger contingencies, but only to some degree. Time properly spent during this stage has the potential to create the biggest positive impact on a project's success.

It is better to have to wait longer for a thorough and accurate study to be completed than to hastily jump into the relocation projects, so that decisions that are made as a result are more likely to be good ones. There are more and less risky options to make up delays in later phases of the project. Make sure the group making these estimates is very familiar with research projects and research sites. A "big name" contractor — however effective and efficient — may not be the best choice. A smaller, and "less expensive" contractor may not necessarily have the right experience.

***Independently confirm any set of estimates with someone experienced in both estimating and research facilities.*** Do not simply accept a confirmation from the original source that the estimate is accurate. If necessary, make sure you talk directly to the estimator and confirm that they understand the specific requirements and have done the cost estimation accordingly. Ask them for non-research figures for comparison (For instance, if they suggest that they have addressed the costs of a research HVAC system, but then provide a cost for an office-based HVAC system, only 10% less, you know they don't have a clue). Develop a very skeptical attitude, and always presume that the actual costs will be greater than the estimated ones until you get the final estimates from the contractor who will actually do the work.

***Develop a detailed design basis for what you are expecting to get.*** Everything needs to be included. Not just sizes and spaces, but how much power is required and in what areas, how you expect it to be distributed, whether or not you want the facility (building panels) to be separated from the research panels so that building maintenance does not shut down research equipment.

*Ultimately, the design basis needs to be clear and not open to potential misinterpretation. Have an experienced research engineer review the design basis for clarity and completeness*

Similarly, you need to be clear about what type of casework you expect, what type, purity and quantity of utilities you need, and a thousand other points. This will be tedious and time-consuming and often is best done by someone familiar with both research and such documents.

Ultimately, the design basis needs to be clear and not open to potential misinterpretation. Have an experienced research engineer review the design basis for clarity and completeness. Always remember that creating 100 pages too many is a trivial cost, and one paragraph too few can lead to disaster.

***Make sure the design firm is experienced with research support, and knowledgeable about research-specific codes and standards.*** Be sure that the design firm will assign their experienced personnel (with knowledge of both research and facility design) to your project, rather than assigning less-costly but less-knowledgeable personnel. Make sure you test their recommendations for safety and operability. Listen carefully to anyone raising concerns, as they often have become aware of some critical issue that has been missed. This author has seen many cases where drawings and submittals have received only cursory reviews and thus obvious problems or issues have been missed. If you can't spend the time and effort to do it right, it won't be done right.

***Analyze your needs carefully and consider all the implications of new systems or approaches.*** Often, a new way is proposed to address an existing problem, which excites great interest and appears well worth the cost. However, once implemented, the new system or approach may incur a lot of additional work and lead to unanticipated additional problems. For example, it is easy to request overhead utilities to allow benches to be repositioned as needed, but have you considered how you will bring these down to the work areas safely and easily? Is the use of hoses carrying high-pressure hazardous gases really the best approach? Question the obvious solutions or new technologies to try to identify potential issues or problems that could arise.

Be even more skeptical about the needs for additional special features; they often are unsupported by actual requirements. I have seen numerous laboratories with expensive casework to facilitate flexibility covered with fixed equipment that never moves. In many cases, the funds and effort could probably have been better used elsewhere. Consider a "cold eyes" (independent) review of the proposed design and any additional features.

***Manage the organization's expectations.*** A key purpose of management is to provide leadership and direction. However, sometimes this effort results in unreasonable expectations that need to be rapidly brought back to earth — before they become so entrenched that they

lead to inevitable lack of enthusiasm for the project. You need to be clear that not everything will be brand new (most lab-relocation projects involve moving a lot of old stuff). Not everyone will get all they want. The new spaces will almost certainly not be as large as we would all like, nor set up as perfectly as we might hope. The new location will be better — but within the prevailing constraints.

Plan to spend an incredible amount of effort planning for the relocation. Assume you will need to trace out all existing equipment and wiring, and develop or update all existing documentation. Be realistic about the effort this will entail and the resources available. Allotting just a few hours or days per week for each person to do this work is not realistic. A part-time approach either will not get the job done or will do the job so poorly as to be useless. Assume you will need to carry out every hazard analysis and risk assessment several times to completely address all of the potential effects of the new location. Recognize that every procedure will need to be reviewed for applicability in the proposed new laboratory location, revised as needed, and occasionally replaced.

***Make sure you get a realistic estimate of the cost and schedule required to relocate all equipment.*** This requires research-knowledgeable personnel who are also good estimators — a rare combination. Make sure everyone is clear that if the work is not on the list, it will not be done. Develop a procedure that will ensure that research personnel will devote adequate time to review and understand all plans, layouts, drawings and so on. Often, personnel are busy with other pressing matters, and make the relocation a secondary consideration, but then raise real (but-hitherto-unarticulated) requirements that can destroy even the best plans during the actual implementation (Figure 4).

Recognize that every piece of equipment will likely require some extra work to get it working again in its new home. Added steps, such as extending a utility, adding a more convenient valve, moving a blocked gage, will all arise, so be skeptical of any simplifying "plug-and-play" assumptions — they are usually wrong. (This author once spent extra weeks adding enough outlets for a laboratory to be sure such "trivial" equipment would have sufficient access to power.)

Plan for a small amount of time and effort in every laboratory or major area to address those items that escaped everyone's review but are going to be needed. The lack of a vice, the missing air hose, the sudden realization that this or that needs to be raised or lowered — these are the types of things that will constantly surface and must be addressed. Recognize that any changes between the time the plans and drawings are finalized, and the actual relocation will probably be missed unless there is a very well-managed system to get it included. Adding it as a last-minute change order will always be proportionately more expensive as it always

involves rework (in terms of design or construction).

Consider putting a freeze on any changes as the relocation date approaches. (This is easy to mandate but almost impossible to enforce.)

***Assemble a dedicated project team, working full time on the relocation, if possible.*** Part-time efforts always take second place and result in little real progress. Make sure the team has enough expertise in the organization's needs, estimating, scheduling, design and evaluation. Engage specialists or subject matter experts as needed. Be careful of assigning personnel who are passionate but may have tunnel vision. The outspoken activist who has pushed for more hoods for years will often take this as an opportunity to force that vision on the organization. And anything carried to excess or — more commonly — implemented impulsively without careful, dispassionate, wide-ranging analysis — is usually sure to create major issues.

How much will this cost? A lot depends on how you assign the work and the charges. If you assume your current staff is already compensated (and thus is "free" to the project), your cost estimate will yield a much lower figure than if you charge their time (at full rate) to the project. If you accept that your current staff is effectively down for months for the relocation, you get a much lower cost than if you hired contractors to do the vast majority of the work and your staff was only down for a few weeks during the actual relocation. If you need to modify, rebuild or replace significant equipment, you will get a much higher cost than if you do not need to do anything.

Is the recommissioning considered a project cost or an operating cost? These, and similar issues make giving typical figures difficult. My experience suggests that almost all relocations are in the range of $150–400/gross square foot (GSF). Efforts to obtain lower costs usually just transfer the actual costs to the operating budgets, and this frequently engenders significant additions due to lack of planning and stewardship.

How long does it take? Again, a lot depends on your plan. Do you try to move in small sections so only a portion of your total research operation is down at any one time, or do you shut down everything for an extended period? Is the facility complete and ready to move into all areas, or are modifications required? Is the facility relocation being completed piecemeal, thus dragging out the relocation? Are you resource-limited in the move and so have to carry it out in phases? Do you have commitments that require you to schedule relocations around them? And, finally, smaller relocations are usually much faster than larger relocations, as there are (usually) fewer constraints. Hence the range of durations are even wider. Typical durations for tightly phased, constrained relocations are 3,000–5,000 GSF/month. Typical ranges for essentially unconstrained relocations can be as high as 10,000–30,000 GSF/month. Schedules are usually constrained by how much downtime the organization can tolerate and, for larger relocations, how much effective contractor staffing is available, so these figures can be highly variable.

In summary, laboratory relocations create interesting challenges and such projects are often much more difficult than realized. If you understand the major issues and take the time and effort to address them properly, you will be able to settle into your new home with significantly less downtime and fewer problems. ■

*Edited by Suzanne Shelley*

## Author

ate after almost 40 years at ExxonMobil Research and Engineering, where he was involved in the design, construction, and support of pilot plants and laboratories for ExxonMobil's research site in Clinton, N.J., as well as affiliates worldwide. Palluzi is the author of two books, and numerous articles and presentations. He is a past chair of the AIChE Pilot Plant Committee, ExxonMobil's Pilot Plant and Laboratory Safety Standards Committee, and ExxonMobil's Safe Operation Team for their Clinton Facility. He is on the National Fire Protection Association (NFPA) NFPA-45 Fire Protection for Laboratories Using Chemicals and NFPA-55 Industrial and Medical Gases committees. Palluzi also teaches several courses for the University of Wisconsin's Dept. of Engineering Professional Development. He has B.E. and M.E. degrees in chemical engineering from Stevens Institute of Technology.

IFAT (May 14–18, Munich, Germany; www.ifat.de) is the world's leading tradefair for water, sewage, waste- and raw-materials management. This year, two additional halls have been added, with more than 3,100 exhibitors expected to participate, presenting the latest products and services spanning the environmental sector, from sewage-treatment plants to the use of comminution machines in refuse treatment. The innovations presented at IFAT aim to promote the sustainable use of the available resources in order to protect and improve our quality of life and the state of the environment.

A sample of some of the new products being exhibited at IFAT 2018 is presented below.

KSB

Gebr. Lödige Maschinenbau


Endress+Hauser

## New gigantic pumps for wastewater transport

In response to the worldwide increase in extra-large wastewater projects, this manufacturer has significantly extended its range of large, dry-installed wastewater pumps (photo). An extra 15 sizes have been added to its Sewatec pump series. The maximum flowrate of the largest version will be up to 33,000 $m^3/h$ with a drive rating exceeding 1 MW. The Sewatec series comprises horizontally or vertically installed, single-stage volute casing pumps in back pull-out design. Depending on the fluid handled, they can be fitted with a variety of impeller types, such as multi-channel impellers and free-flow impellers or single-vane impellers. The casings come with a replaceable casing wear ring. The suction nozzles are always arranged axially. For the discharge nozzles, users can choose between a radial and a tangential arrangement. Hall B1, Stand 227/326 — *KSB SE & Co. KGaA, Frankenthal, Germany*
**www.ksb.com**

## A continuous mixer for many different applications

The low-maintenance Ploughshare mixer KM (photo) is suitable for processing powdery, fibrous or granular solids, as well as liquids and pastes. Granulation processes can also be carried out with the continuous mixer at minimum dwell time. The continuous mixer is based on the patented, mechanically generated turbulent fluidized-bed process. During this process, Ploughshare shovels rotate close to the wall in a horizontal, cylindrical drum. Their peripheral speed and geometric shape take the mixing components off of the drum wall and toss them into the free mixing compartment from the product bed. Intensive mixing is achieved even at extensive throughputs of material to be mixed. An excellent homogeneity and consistent reproducibility of the final product is achieved during short mixing or dwell times of only 25 to 60 s, says the company. The smallest model has a drum capacity of 5 L and a throughput of 0.25 $m^3/h$, depending on the dwell time and filling level. The largest model has a drum volume of 57,000 L and a throughput of around 1,300 ton/h. Hall A4, Stand 441 — *Gebr. Lödige Maschinenbau GmbH, Paderborn, Germany*
**www.loedige.de**

## Digitalization in the water and wastewater industry

In line with a comparable advance in development in industrial production, known as the Industrial Internet of Things (IIoT) or Industry 4.0, the German Water Partnership (GWP) is launching a "Water 4.0" discussion aimed at exploring the significance of this technology-driven change to the water industry. In this context, this company is demonstrating some of its initial application scenarios (photo). This includes measurement instruments integrated with Heartbeat Technology, which tests the reliability of the instrument and helps users to improve their processes. The instruments supply digital diagnostic data, verify performance and monitor process data to create a predictive maintenance and process optimization strategy. Analyzers for monitoring phosphorus and phosphate, as well as new compact sensors integrated with the company's proven Memosens digital technology, help operators monitor wastewater processes and optimize process control. Hall C1, Stand 415/550 — *Endress+Hauser AG, Reinach BL, Switzerland*
**www.endress.com**

## Digitalization increases efficiency and security in the water industry

*Siemens*

At IFAT, this company is focusing on the digitalization of water and wastewater plants (photo). The solutions on display cover the entire lifecycle of plants — from planning through to operation and maintenance, helping to sustainably reduce energy consumption and lower the overall costs. Companies and municipalities are increasing both the efficiency and security of supply by, for example, planning, simulating and optimizing plants and processes using a digital twin. Innovations include new hardware concepts and industry-specific modules for the Simatic PCS 7 process control system, as well as automation over the TIA Portal using Simatic S7-1200 and S7-1500 and cloud-based solutions for the optimized use of pumps. A digital twin of the real plant provides users with significant advantages over the entire lifecycle of the plant. Hall A1, Stand 439 — *Siemens AG, Munich, Germany*
**www.siemens.com**

## A powerful screw blower in a compact package

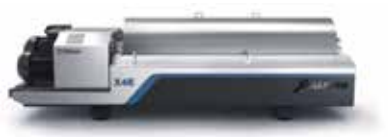

*Kaeser Kompressoren*

The CBS (photo) now brings all the advantages of screw blower technology to lower-flowrate applications. For municipal or industrial wastewater treatment plants requiring compressed air with differential pressures up to 1,100 mbars, the CBS screw blower delivers flowrates from 2.3 to 12.2 $m^3$/min, with power from 7.5 to 22 kW. The CBS is also suitable for applications such as production of aeration air in water treatment and for bioreactors, flotation and fluidization. It is up to 35% more efficient than conventional rotary blowers, and even offers significant energy advantages in the two-digit range compared to other screw and turbo blowers on the market, says the company. One screw blower is so powerful that it efficiently covers the control range of two or three rotary blowers. Hall A1, Stand 143/242 — *Kaeser Kompressoren SE, Coburg, Germany*
**www.kaeser.com**

## Slash operating costs for sludge dewatering with this centrifuge

The new Xelletor series decanter centrifuge (photo, p. 68) is said to provide better sludge-dewatering performance with lower energy con-

Flottweg



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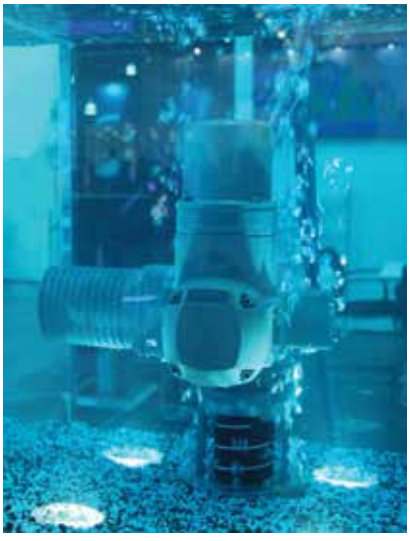


Auma Riester

Hiller

sumption. The rotor, and especially the scroll, have a design never seen before. Consumption of polymer flocculant is significantly reduced in the Xelletor series thanks to an entirely new intake configuration. Depending on sludge quality, the centrifuge can save about 20% on energy while providing significantly better performance over traditional systems, says the company. Additional benefits include: more power, which increases throughput by up to 15%; drier cake, which can reduce the volume of biosolids by as much as 10%; and reduced operating costs by 20% due to lower energy consumption and polymer consumption. Hall A1, Stand 550 — *Flottweg SE, Vilsbiburg, Germany*
**www.flottweg.com**

## Twin-shaft grinders for wastewater channels

This company is presenting its new generation of the twin-shaft grinder XRipper, which is used to prevent blockage of pumps and entire channels in wastewater-treatment plants. The new XRipper Giant (XRG) series (photo) is suitable for even large channels and very high flowrates up to 3,000 $m^3$/h. The one-piece Ripper rotors have a length up to 1.4 m, and a support shaft is no longer required. This also applies to the new, extra narrow and long model in the XRipper XRC100 series. The extra-slim models of the XRipper XRC100 series are suitable for narrow, high channels, and can be installed in channels with a width of only 30 cm and achieve throughput of up to 690 $m^3$/h. Hall B1, Booth 347/446— *Vogelsang GmbH & Co. KG, Essen/Oldb., Germany*
**www.vogelsang.info**

## Explosion-proof version of underwater actuator

The new explosion-proof version this company's underwater actuator (photo) features innovative sealing, non-intrusive parameterization and separately mounted controls. These actuators are suited for continuous underwater use, thus considerably extending the scope of application of electric actuators in water supply systems, hydropower plants, civil engineering constructions for water applications and specific underwater applications. The new explosion-proof version is available for sewers and sewage pits, where fermentation gases generate a risk of potentially explosive atmospheres during dry periods. A universal sealing system combined with comprehensive corrosion protection qualifies these actuators for underwater use. SA/SAEx actuators in sizes 7.2 to 16.2 for continuous underwater use are qualified for up to 15 m head of water, with higher heads of water available on request. Actuators in the explosion-proof version meet ATEX requirements. Hall C2, Stand 141/240 — *Auma Riester GmbH & Co. KG, Müllheim, Germany*
**www.auma.com**

## Reduce operating costs with sludge disintegrating centrifuge

This company's centrifuges can be operated with an additionally installed lysing device (photo). This lysing device is attached in the area of the sludge discharge openings and uses the existing kinetic bowl energy. This means that the additional power consumption of 0.02 to 0.05 kW/kg can also be kept correspondingly low. The disintegration effects in the thickened waste-activated sludge (WAS) essentially take place by impact and shear forces generated by rotating knife blades in the labyrinth and the lysing chamber at high circumferential velocity. The lysing device consists of a labyrinth with a lysis chamber fitted with window openings. Fork blades fitted onto the centrifuge bowl rotate through the lysis chamber, and these blades are protected against wear with tungsten carbide plating. From the discharge openings of the centrifuge, thickened waste-activated sludge thrown out at high speed flows through the lysis chamber in the axial direction. Using a disintegration process to generate technical and economic advantages for further sludge treatment leads to reduced viscosity and better pumping properties, increased degradation of the organic part, increase in gas yield and improved drainage behavior. Hall A1, Stand 150 — *Hiller GmbH, Vilsbiburg, Germany*
**www.hillerzentri.de**

*Gerald Ondrey*


Achema — the world forum and tradeshow for the chemical process industries (CPI) — is hosted by Dechema e.V. (www.dechema.de) every three years in Frankfurt am Main, Germany. This year, the event will take place June 11–15 and will feature some new focal topics, including logistics for chemicals and pharmaceutical manufacturers and flexible manufacturing in the age of Industry 4.0 technologies. Achema's 2018 exhibition boasts over 3,800 registered exhibitors spread over numerous exhibit halls, who will be showcasing some of the world's newest and most advanced products and technologies. This year, exhibitors are divided into 11 distinct exhibition groups: Engineering; Research & Innovation; Instrumentation, Control & Automation Techniques, Industrial & Labor Safety; Laboratory & Analytical Techniques; Literature, Information, Learning & Teaching Aids; Mechanical Processes; Thermal Processes; Pharmaceutical, Packaging & Storage Techniques; Pumps, Compressors, Valves & Fittings; and Materials Technology & Testing. In this first of two Achema Show Previews — the second will be in our June issue — is a small selection of offerings from Achema's 2018 exhibitors.

*KSB*

## This new system puts pumps into the internet of things

A new pump monitoring system, called KSB Guard, consists of networked vibration and temperature sensors fitted directly to the pump (photo), thereby making equipment availability at the plant level transparent. The system ensures that changes in the operating behavior of the machine are detected at an early stage, and maintenance work can be better planned, without having to be on site with the pump. Unlike previous systems, KSB Guard is well suited for retrofitting, says the company. The sensor unit is attached to the bearing bracket or the drive lantern of the pump using a magnet and adhesive, and can be mounted during operation, with no need for changes to the machine. Data, captured hourly, can be transferred directly and wirelessly (in encrypted form) to the cloud via a gateway for processing. Users can query the status data of all monitored pumps at any time and from any location using their mobile phone, a tablet or a PC. The aim of the newly developed solution is to create a cost-effective interface to the internet of things (IoT) for all types of pumps. Hall 8.0, Stand H14 — *KSB SE & Co. KGaA, Frankenthal, Germany*
**www.ksb.com**

*Frewitt*

## High-containment system with an integrated mill

This company's new containment system with an integrated mill (photo) is mounted on a mobile base consisting of an isolator, a continuous liner system (CLS) and a Fredrive-Lab mill. The Fredrive-Lab is mounted on a lifting column, forming the core of the system. Using this flexible mill, heat-sensitive, hard, crystalline and fibrous products can be pulverized, de-agglomerated, calibrated and milled ($D_{90}$ to 10 µm). Depending on the milling process and the material to be processed, the operator can choose between six different milling heads, which are easily interchangeable on a single flange. The milling heads can be introduced and taken out using a CLS mounted on the side and on the bottom of the isolator. This is also used for changing the individual screens and rotors, as well as for feeding the products to be processed. A frequency-regulated fan permanently controls the negative pressure in the isolator. Hall 3.1, Stand D27 — *Frewitt AG, Granges-Paccot, Switzerland*
**www.frewitt.com**

## A new non-invasive signaling device for rupture discs

The NIMU (photo, p. 71) is the latest non-invasive signaling device for rupture discs. Conventional signaling devices require cables to be mounted on the rupture disc, which must then be routed out through the rupture disc holder. Conversely, with the NIMU, a signal indicator is attached to the rupture disc during the manufacturing process. The actual sensor is screwed into a blind tapping in the rupture disc holder, where it monitors the position of the signal indicator on the rupture disc. This means that the wiring only starts outside the rupture

disc holder. After an overpressure event, and the associated opening of the rupture disc, the outlet part of the rupture disc holder must be removed, the rupture disc replaced, and afterwards the system can be put back into operation. Hall 9.1, Stand C4 — *Rembe GmbH, Brilon, Germany*
**www.rembe.de**

## A showcase for valve intelligence at all industrial levels

This company will introduce digital solutions designed to advance decentralized valve intelligence. The Sam Digital Hub, a state-of-the-art digitization and automation platform by Ubix that operates on the cloud-based "software as a service" approach, makes it possible to log, save, process and exchange all data in process automation systems. Other pilot setups will demonstrate pioneering applications for IoT and Industry 4.0 environments. Smart field units serve as hubs in networked valves and their connection, for example, to SAP's Asset Intelligence Network (AIN). In addition, a pilot setup of an Ethernet field solution will be on display to show how devices can be interconnected at the field level. Hall 11.1, Stand C85 — *Samson AG, Frankfurt am Main, Germany*
**www.samson.de**

## Two mechanical separators for a wide variety of applications

With the AC 1200 separator (photo), this company is starting a new product line of high-performance separators for small and mid-sized operations. The AC 1200 was configured as a skid solution. This allows its uncomplicated integration into existing processes, making it quick and flexible. In parallel, this company is also presenting its Z2E decanter centrifuge. Thanks to its compact design, the Z2E handles key functions in many different areas of the biotechnology and chemical industries. The smallest modular machine in the Z series, the Z2E can be customized for different requirements so that fluctuating production conditions and frequent product changes are simplified, making it suitable for small batches and quick cycles. Hall 5.0, Stand A86 — *Flottweg AG, Vilsbiburg, Germany*
**www.flottweg.com**

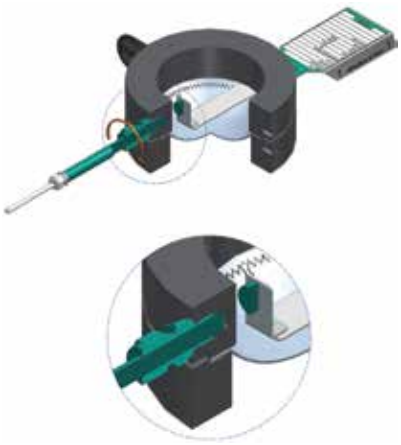
## Hermetically sealed, all-ceramic chemical pump

The MPCV centrifugal pump is self-regulating, can run dry and is hermetically sealed. Therefore, this vertical pump does not require a minimum volume flow or a large static head. The three-phase-compatible pump is now also available as an all-ceramic version, the K-MPCV-AN (photo). The use of silicon carbide ceramic further extends the service life of the pump. Equipped with a magnetic coupling and roller bearings, which are permanently dry-running, the intrinsically safe K-MPCV-AN operates without bearings in the pumping liquid. The shaft-gap seal concept is based on the complete hydrodynamic relief of the bearing and seal unit. Back vanes and a gas barrier prevent product vapors from penetrating the bearing unit. Like all pumps in the V-AN range, the K-MPCV-AN features control characteristics that adapt automatically to variable feedrates. Hall 8, Stand C1 — *Paul Bungartz GmbH & Co. KG, Düsseldorf, Germany*
**www.bungartz.de**

## Separation technology — from column internals to retrofits

The recently introduced MellaCarbon line of column internals (photo) delivers advantages for corrosive applications, including exposure to caustic solutions and non-oxidizing inorganic acids, including hydrofluoric acid and carboxylic acids. Further developments have been made in tray performance, with increased capacity and improved downcomer technology that enhances performance. According to the manufacturer, Mellacarbon combines all the advantages of a structured gauze packing with the corrosion resistance of carbon. Mellacarbon column internals provide high wettability and thermal stability (greater than 400°C). The company has also implemented improvements to random packing applications and its NeXRing technology. Integration of the latest technology with existing infrastructure is very important, and turnkey service using skid-mounted solutions that minimize costs and process disruption are offered. Hall 4.0, Stand D48 — *Sulzer Chemtech AG, Winterthur, Switzerland*
**www.sulzer.com**

Rembe



Flottweg

Paul Bungartz

Sulzer Chemtech

Elaflex

## Hose assemblies to meet a wide variety of application needs

The new ElaSil silicone hose range (photo), which complements the company's ElaPharm pharmaceutical hoses, conform to FDA and USP Class VI and meet the 3-A Sanitary Standard. The hose sizes range from DN 13 to 102 mm, and are assembled to user specifications, with crimped couplings. Also on display is the EasyLoc version of the company's Camlock product range. EasyLoc features an automatic lever lock to avoid unwanted disconnection during operation, for example due to excessive pulsation. The couplings are available in sizes DN 13–50 mm. Hall 8.0, Stand L93 — *Elaflex – Gummi Ehlers GmbH, Hamburg, Germany*
**www.elaflex.de**

Dr. Thiedig

## Fast measurement of degassed acid conductivity

The Digox 602 dac (photo) is an optimized measuring device for monitoring the degassed acid conductivity in the water-steam cycle. The unit performs a fast, dependable measurement of the acid conductivity without the influence of $CO_2$. In the standard version, the measurements of the specific conductivity, the acid conductivity and the pH-value calculation are available. The degassing takes place without increasing the media temperature. Due to the short downtime (less than 90 s) of the degassing, the device can considerably shorten the startup time for steam turbines. The efficiency of the degassing is over 90% — optionally, the value can be calculated to 100%, says the manufacturer. The device is also available as an upgraded version for existing measurements of the acid conductivity and additionally as a portable, battery-operated version. Hall 11.1, Stand E63 — *Dr. Thiedig GmbH & Co. KG, Berlin, Germany*
**www.thiedig.com**

Countec

## Pumps and pump-monitoring technology to be displayed

The Ensival Moret CAHR pump range for heavy-duty axial flow is suitable for applications involving highly corrosive liquids and slurries. Another product on display will be the OCV range, the latest evolution of the proven API 610-type VS4 pumps that offer reliable performance in demanding applications. In addition to this, the company will have the OHV pump and the Type OH3 overhung, horizontal, centerline-mounted, single stage pump that is API 610 certified. For monitoring the overall performance of pumps, as well as data from specific assets, the company's Blue Box is a flexible and secure software solution that uses existing operational data combined with pump design information to analyze pump operation and optimize it in terms of performance, efficiency and reliability. Hall 8.0, Stand A71 — *Sulzer Pumpen (Deutschland) GmbH, Bruchsal, Germany*
**www.sulzer.com**

## Inspect and count tablets and pills at high speeds

Vicob (photo) is a vision-inspection counting machine that can check each individual piece of product with 100% vision inspection with single-tablet reject prior to filling. With the company's patented hybrid technology that combines the functions of tablet counting and vision inspection, Vicob brings together ultra-high-resolution cameras, tilted, revolving disc-tablet feeding and cylinder-free airflow control for tablet spacing. Additionlly, the company's VC-100 model is capable of processing high-speed product inspection data while maintaining the two-times faster output. Vibratory feeders are replaced by a tilted revolving disc that guides the products to a circumferential edge and directly to the vision counting zone and shutter cylinders are replaced by the flow-control technique that enables single-tablet reject instead of removing the entire container from the conveyor. This concept is different from the existing design, which requires vibrator feeding and shutter cylinder spacing. Hall 3.1, Stand G69 — *Countec Co., Seoul, South Korea*
**www.countec.com**

## Robotic innovations for the pharmaceutical industry

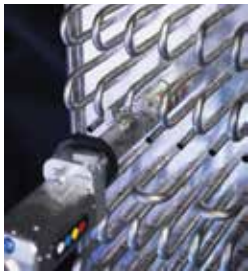
The new TS2 Scara series (photo, pg. 73) represents a complete makeover of this four-axis machine with patented JCS drive technology, significantly shortening cycle times and

introducing a hygienic design that opens up the potential for new applications in sensitive environments. The completely redesigned Scara robot arms now have a modular configuration, and for the first time, feature the company's proprietary hollow-shaft drive that is already available on the six-axis models. This drive technology is the key to the performance gains of the four-axis TS2 and to a unique cleanroom design in which external cabling is eliminated. The new robots are are characterized by their compact, enclosed design with internal media and supply lines. There is no external bundling of cables and thus no irregular contours, sources of mechanical failure or avoidable particle emissions. The machine's design includes completely sealed housing, optional quill protection with a cover affixed with special screws and concealed connections under the robot pedestal with dead spaces systematically excluded. The new product range has four models. Hall 1.1, Stand B47 — *Stäubli Tec-Systems GmbH, Bayreuth, Germany*
**www.staubli.com**


*Stäubli Tec-Systems*

## Orbital weld heads for thin stainless-steel pipes

HX Series orbital weld heads enable users to join pipe elbows to small stainless-steel pipes (for example in heat exchanger construction). The product line has now been expanded to include the HX 12P model (photo), which is specially designed for very compact fin heat exchangers with pipe diameters ranging from 9.5 to 13.3 mm. Using an automated welding technology, pre-mounted pipe elbows, even those in tight pipe bundles, can be welded reliably and quickly (in under 30 s per pipe). The HX 12P features a straight design, which enables easy turning of the head at the heat exchanger. The entire unit can be suspended from a balancer to take the strain off the operator. In addition to the HX 12P, the HX Series also includes the HX 16P for pipe diameters from 15.0 to 16.8 mm and the HX 22P for 18.0 to 22.0 mm. Hall 9.2, Stand D10 — *Orbitalum Tools GmbH, Singen, Germany*
**www.orbitalum.com**


*Orbitalum Tools*

## New technologies for bag filling and testing

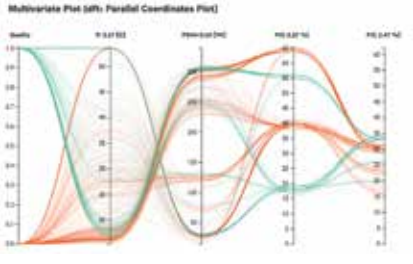
The fillpac FFS (photo, p. 74) is a highly efficient form-fill seal system that is designed for use in the chemical and petrochemical industries. The machine forms bags from a prefabricated tubular polyethylene (PE) film and fills them with users' products. The product range also includes a new bag tester device that is easy to transport and enables users to precisely determine the

Beumer

Marchesini Group


Windmöller & Hölscher

Rheinhütte Pumpen



Hüttlin

venting capacity of any type of valve bag, as well as its suitability for any number of applications, including testing of all paper and plastic layers and glued areas. Hall 3.0, Stand F50 — *Beumer Group GmbH & Co. KG, Beckum, Germany*
**www.beumergroup.com**

## This robotic blister line features built-in predictive maintenance

The Integra 320 robotic blister line, now available with the Valida five-camera infeed system (photo), ensures multi-vision control of the shape, thickness and color of pills. The system also features a near-infrared (NIR) active-ingredient recognition system and a newly developed SCADA system, which checks the mechanical and functional state of the machine by constantly monitoring quality parameters and informing the operator accordingly. Furthermore, the line is also equipped with a predictive maintenance system to pinpoint possible mechanical problems and suggest appropriate scheduled maintenance actions. Hall 3.1, Stand G3 — *Marchesini Group S.p.A., Pianoro, Italy*
**www.marchesini.com**

## This bagging machine has many flexible options for packaging

The Topas SL FFS (photo) is a bagging machine designed to process a wide range of free-flowing bulk solids with capability to handle more than 2,600 bags/h. A variety of product-related features, such as a bypass hopper, a dust-removal system and washing capability, as well as the choice between a gravity dosing and a volumetric dosing method, permits easy adjustment for diverse packaging applications with filling weights ranging from 5 to 50 kg. Hall 3.0, Stand F74 — *Windmöller & Hölscher KG, Lengerich, Germany*
**www.wuh-group.com**

## This cantilever pump is designed for solids-containing media

The RCEV vertical cantilever pump (photo) is designed without a base bearing and has a free-flying shaft, making it suitable for conveying liquids containing solids from containers or open sumps. The double volute casing ensures that radial forces are kept to a minimum, says the manufacturer. The RCEV pump can be equipped with an open or closed impeller with front and back blades, depending on the application. The open impeller is frequently recommended in the case of heavily contaminated media containing solids, as closed impellers may become clogged. The pump is also protected against dry running, due to the raised mounting without a bearing in the conveyed material. Hall 8.0, Stand A24 — *Rheinhütte Pumpen GmbH, Wiesbaden, Germany*
**www.rheinhuette.de**

## New tool provides root-cause analysis for pharma applications

This company is debuting a new data-mining tool (photo) for solid-dosage pharmaceutical production that aims to evaluate existing machine data more effectively to identify and eliminate root-causes of operational problems. Using statistical methods while interacting with a machine's sensors, the tool can examine a large volume of data for very small anomalies and identify reasons for process deviations that might not be obvious at first sight. In general, says the company, production data from just two production batches are sufficient to begin generating insights, but as more data points are available for evaluation over a longer period, more details can be identified the longer the system is employed. Hall 3.1, Stand C71 — *Hüttlin, a subsidiary of Bosch Packaging Technology, Waiblingen, Germany*
**www.boschpackaging.com**

## This imaging system handles both dry and wet media

The Analysette 28 ImageSizer (photo, p. 76) is a particle sizer for dry and wet measurement applications that require accurate and reproducible measuring results for both particle shape and size. The sizer's dynamic-image-analysis optical process provides results for a wide measuring range and delivers multiple shape parameters. For wet measurements with emulsions and suspensions, the device provides an extra wide measuring range of 20 µm through 2.8 mm, an automatic rinsing cycle and a freely adjustable ultrasonic-powered deagglom-

Fritsch

Alfa Laval

Tecfluid

Intertec-Hess

Broadley-James

eration capability. For dry, free-flowing materials, the ImageSizer enables users to identify damaged particles, contaminants, agglomerates or oversized and undersized particles accurately and quickly, and view them in single, uncomplicated images. Hall 4.1, Stand J49 — *Fritsch GmbH, Idar-Oberstein, Germany*
**www.fritsch-international.com**

## New technologies for centrifugal separation

This company's new centrifugal separator for industrial fermentation applications combines high separation area with continuous solids discharge, making it suitable for high-density broths. Its hermetic design ensures very gentle product handling, high separation efficiency and low energy consumption. The new centrifugal separator is suitable for medium-sized batches. The company has also developed new UniDisc discs for its Culturefuge range (photo) of centrifugal separators for harvesting mammalian cells. The discs serve to improve hygienic operations by minimizing the number of deadlegs in a system. The Unidisc design also makes it possible to increase the total separation area and improve separation efficiency, says the company. Hall 4.0, Stand D4 — *Alfa Laval Mid Europe GmbH, Hamburg, Germany*
**www.alfalaval.com**

## Measure flow of conductive materials with low pressure drop

The Flowmid series of electromagnetic flowmeters (photo) is designed for measuring conductive liquids in applications where low pressure drop and infrequent maintenance are required. There are no moving parts or obstructing elements in the instrument, allowing for the passage of solids without retention. The flowmeters can be assembled and mounted in any position, provided that the pipe is always full. Flowmid devices provide good chemical resistance and low power consumption. Available in compact and remote versions, the devices are configurable using a PC and a USB cable using software provided by this company. HART and Modbus communication protocols are available upon request. Hall 11.1, Stand A68 — *Tecfluid, S.A., Barcelona, Spain*
**www.tecfluid.com**

## Instrumentation shelters with a hybrid cooling system

This company is introducing a new style of outdoor shelter for process plant applications, the Peri Shelter (photo), which features a cooling system based on a hybrid combination of unpowered passive and active powered technologies. This shelter provides a reliable operating environment for control, analyzer and instrumentation electronics. All system components that are required for normal operation are accessible via the building's exterior. Panel-mounting enclosures on the exterior provide access to electrical connection and I/O termination points, as well as cooling systems. Touchscreen panels can also be fitted to external walls, allowing operators on the ground to monitor a control element, such as a PLC, or make adjustments to control programs locally via an inspection door. The shelters employ glass-reinforced polyester (GRP) materials that are very insulating and provide surface protection in extreme environments, including those with very high levels of ultraviolet (UV) light and abrasion from sand or dust. Hall 11.1, Stand F61 — *Intertec-Hess GmbH, Neustadt, Germany*
**www.intertec.info**

## This dissolved-oxygen sensor avoids bubble-induced errors

The OptaProbe (photo) is a smart optical dissolved-oxygen (DO) sensor for use in bioprocess applications with autoclave or steam-in-place (SIP) requirements. OptaProbe sensors feature this company's DeflectorCap with a 45-deg angled sensing surface, which deflects sparge bubbles in any insertion orientation and SpargeSafe firmware, which eliminates bubble errors. The OptaProbe has a sophisticated, built-in signal-filter system that recognizes measurement noise caused by bubbles and filters it out of the signal. This significantly increases measurement precision in challenging bubble-filled aeration environments. Measurement errors caused by bubbles striking the measurement surface are drastically reduced and in many cases eliminated. Hall 11.1, Stand F76 — *Broadley-James Ltd., Silsoe, U.K.*
**www.broadley-james.eu** ■
*Mary Page Bailey and Gerald Ondrey*

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## Inside:



# Ultra-High Efficiency Gas Absorption and Particulate Collection in a Space Saving Design

*Now Achievable with Proprietary Bionomic Scrubber Technology*

## Overview

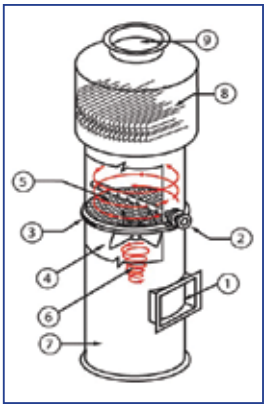
The patented RotaBed™ Fluidized Bed Scrubber represents a major breakthrough in ultra-high efficiency gas absorption and particulate collection in a space saving non-fouling design. RotaBed is the ideal technology for applications involving particulate laden gas streams or when handling high solids content or scale forming scrubbing liquids.

The key to the scrubber's superior performance is a unique swirl induced Coriolis grid that achieves much greater fluidized bed stability, resulting in more efficient gas mixing and transfer efficiency than less advanced designs. This unique approach to gas-liquid fluidization is accomplished without the need for marbles or plastic spheres that are prone to fouling or replacement due to wear. RotaBed's "packless", highly plug resistant grid cross section is up to 99% open in the fluid contact scrubbing zone and allows the scrubber to deliver exceptionally high gas throughput capacity - over three times greater than comparable size packed towers or tray scrubbers for higher scrubbing efficiency in a smaller diameter vessel.

Designed to handle gas capacities from 500 thru 25,000 cfm, RotaBed is available in mild steel, 304, 316, and AL6XN Stainless Steels, High Nickel Alloys, Titanium FRP, FRP-Dual Laminate, and Polypropylene. Pressure drop range is 1..75" thru 15" w.c. with particulate removal efficiencies of 3 microns and above from 97 to over 99.9%, and water soluble gases up to 99.99%

## How It Works

During operation, gas with contaminants enters the RotaBed gas inlet(1) and flows upward. Scrubbing liquid is introduced through fully open non-clog pipe distributors(2) onto the surface of the patented RotaBed Coriolis induced fluidizing grid(3). Single or multiple grid stages are incorporated depending on the number of transfer units required to meet the needed pollutant removal efficiency. The high velocity gas travels in an angular upward path and fluidizes the liquid on the large open area grid surface. Unlike low efficiency static plug flow fluidized beds, the RotaBed shaped grid design utilizes swirl inducing vanes(4) to dramatically increase mass transfer and particulate collection via creation of a rotating Coriolis motion fluidized bed(5). Scrubbing liquid with captured pollutants then vortex drains(6) into the slump(7). The RotaBed cleaned gas passes through a two stage droplet removal stage(8) and exits through the gas outlet(9).




**How RotaBed™ Works**

**www.bionomicind.com**

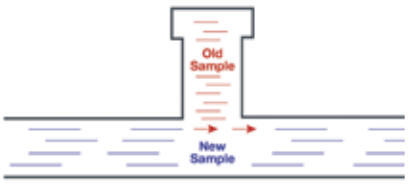
# Sampling System Training Enhances Reliability

*Swagelok reveals "aha" moments from process analyzer sampling system trainees*

Sampling system trainees often experience many epiphanies during training sessions. That's no surprise, as process analyzer sampling systems are among the most challenging systems in a plant to design and operate accurately. Here are a few "aha" moments **Swagelok** has observed during the company's training courses:

## "Time Delay Can Be Longer Than Expected"

Most trainees are amazed at how late some analyzer measurements can be. The industry standard is a one-minute response time from pulling a sample to obtaining a reading. This short time frame provides near real-time readings of process conditions, so operators can make immediate adjustments and minimize wasted product. However, the time to obtain a reading could be extraordinary, even with the analyzer mounted close to the process tap. Adjusting the system design is the only way to reduce that time delay.




**In this deadleg configuration, old sample trapped in the tee formation leaks into the main fluid stream, contaminating the new sample.**
**© 2013 "Industrial Sampling Systems"**

## "My Sample May Not Be Representative"

Time delay is a critical issue to correct because it affects how "representative" the sample is of the fluid in the process line at the time of obtaining an analyzer reading. Yet, even when you take a proper sample and limit time delay, the sample may still become unrepresentative due to the system's design. For example, deadlegs in the system may trap old samples that can bleed into the new sample, creating a mixed sample that isn't true to real-time process conditions.

## "Vaporizing a Liquid Can Be Very Difficult"

Many trainees think vaporizing a liquid sample is easy – but a lot can go wrong. The goal is to convert the liquid to all vapor instantly by dropping the liquid's pressure rapidly. However, instead of flashing the whole sample into a vapor, the system could unintentionally create a fractionated sample through a combination of vaporization and evaporation. In this case, lighter gas molecules that evaporate first move downstream to the analyzer, while heavier liquid molecules remain behind. As a result, the sample reaching the analyzer no longer accurately represents the product taken from the process line. Learning how to adjust temperature, pressure, and flow, can help to prevent this scenario.

Analytical sampling system design is a lifelong journey of discovery. Swagelok's hands-on training courses covering design and maintenance practices can help technicians enhance skills and discover their own "aha" moments that can lead to more accurate and reliable analyzer readings. **www.swagelok.com/en/Services**

# A classic mixing tool for the petroleum industry

*Ross LPD Static Mixers are rugged, reliable devices that combine excellent inline mixing with minimal pressure loss*

**Ross** Low Pressure Drop (LPD) Static Mixers are used throughout the oil and gas industry for turbulent-flow mixing applications.

**Shown are removable LPD mixing elements supplied with retainer ring and flanged housing**

These heavy-duty low-maintenance devices serve in continuous operations where high performance and accuracy are required, such as on-line water determination of crude oil; dosing of various additives into gasoline; blending different kinds of fuel oils; gas-gas blending; and pipeline reactions, among others.

Static mixers have no moving parts and the energy for mixing is available in the form of pressure. Pressure loss – a natural consequence of static mixing – sometimes becomes the deciding factor in mixer selection. The LPD Static Mixer remains a classic choice for many inline blending requirements due to its simple and durable design capable of uniform mixing with little pressure loss. The mixer elements consist of semi-elliptical plates carefully positioned in series to split and rotate the product 90 deg. in alternating clockwise and counterclockwise directions.

LPD mixers in diameters from 1 in. through 2.5 in. are welded to a central rod, while larger elements are welded to four outside support rods for maximum rigidity and stability. Units as large as 48 in. diameter can be supplied as stand-alone mixer elements or as modules complete with a mixer housing and injection ports.

Established in 1842, Ross is one of the oldest and largest mixing equipment companies in the world. Ross mixing, blending, drying and dispersion equipment is used throughout many industries in the manufacture of foods, adhesives, electronics, coatings, cosmetics, pharmaceuticals, plastics and composites.

**www.staticmixers.com**

# Tank gauging solution reduces total cost of ownership

*A case study shows how Endress+Hauser's Proservo NMS5 and Promonitor NRF560 are easy to retrofit to existing tanks, combining accuracy, reliability, and low cost of ownership*

One of the world's premier plastics, chemicals and refining companies needed a tank gauging solution for a group of spherical tanks holding light hydrocarbon liquids, reports **Endress+Hauser**.

Some of the tanks were still fitted with their original float-and-tape gauges in stilling wells. Most tanks had been upgraded to a newer servo-based float system. A few used free-space radar level measurement, but with unsatisfactory results.

The customer wanted a standardized, reliable, and accurate tank gauging technology requiring little or no modification to the existing tank mountings. The solution was the Proservo NMS5 intelligent tank gauge from Endress+Hauser. This servo-based float system gives high accuracy (±0.7 mm) in custody transfer and inventory control.

Endress+Hauser also supplied Promonitor NRF560 local display units for tank-side monitoring and control. Additional support included project management, fabrication, and commissioning.

The same customer's next group of tanks was a bigger challenge: to integrate new level gauges with an existing digital communication system. Cables were already in place to each of the various spheres, bullet tanks, and floating-roof tanks, but were not in use on those tanks that were not fitted with level transmitters.

**Proservo NMS5 atop a storage tank**

Endress+Hauser checked the setup and confirmed that the existing communications system had enough spare capacity to handle the new gauges. The company supplied Proservo NMS5 gauges using the BPM protocol, programmed with digital addresses to fit the requirements of the legacy software.

Endress+Hauser was able to commission the new instruments in just two weeks. The new gauges, including RTD temperature data, showed up in the communications system alongside the existing gauges. Endress+Hauser also supplied Promonitor NRF560 units for monitoring and control.

Using existing wiring and software helped to lower the total cost of the project. Another key issue in keeping costs down was the fact that Endress+Hauser provided the customer with all the necessary custom hardware to allow the new gauges to be mounted without modifying the tanks.

**www.us.endress.com**

# Providing leadership in process heat transfer

*With increasing investments in research, testing, software, and services, HTRI strengthens its position in process heat transfer technology.*

HTRI is a leading source of process heat transfer technology. Incorporated in 1962, the corporate consortium has the staff, expertise, half a century of proprietary test results, and state-of-the-art test units and auxiliary equipment to perform advanced experimental research. HTRI technology and services are used by companies worldwide to design, operate, and improve performance of heat transfer equipment.

The Research & Technology Center (RTC) is a unique, multimillion-dollar facility located at corporate headquarters in Navasota, TX, USA. It provides a controlled environment for testing with eleven operating research units, support facilities, and equipment.

Contract services are available to members and non-members of the consortium. Utilizing these wide-ranging services, companies can address diverse heat exchanger issues to improve exchanger performance or throughput, reduce fouling, or troubleshoot equipment. The industrially-focused research is augmented by computational fluid dynamics (CFD) and quantitative flow visualization, including high-speed video and particle image velocimetry (PIV). HTRI also offers industrial scale device/proof tests and assessments of prototype heat exchangers for a wide range of single-phase boiling and condensing applications. In addition, fouling propensity can be tested for crude oils and other hydrocarbon feedstocks.

**The Air-Cooled Unit, the latest addition to the RTC, is designed according to API 661 standards, with reconfigurable mechanical components and options for forced- or induced-draft orientations, removable tube bundle air seals, and box or shaped plenums.**

HTRI software solutions are based on decades of innovative research. Throughout the world, the acclaimed HTRI Xchanger Suite is considered the most advanced thermal process design and simulation software. HTRI continues to offer new products such as SmartPM, Exchanger Optimizer, and Xfh Ultra.

Technical support is free to members and provided by staff with relevant expertise. HTRI training assists thousands of end-users worldwide through onsite courses and workshops, as well as online webinars. Sessions are based on robust research results, reliable software methods, and relevant industry standards.

**www.htri.net**

# Single-source provider cuts costs and boosts uptime

*Team Industrial Services offers a wide range of specialized services, with a single point of contact for improved efficiencies and maximum cost savings*

Subcontracting vital parts of a project to multiple sources can lead to longer turnaround times, lessened quality and increased costs. Forming a strategic relationship with a well-vetted supplier is proven to create shared savings and improved operational efficiency.

**Team offers critical inspection, maintenance, repair and integrity management services to customers worldwide**

The key is in the selection process. Business objectives of both organizations must be in line with one another for a long-standing agreement to take place. Are the companies' core values compatible? Can the service provider perform the work within the cost parameters? Does the contracted company have relevant experience and people with the right skills located near the company's work sites?

As a single-source provider, **Team Industrial Services** offers critical inspection, maintenance, repair and integrity management services to its customers. The company provides an integrated approach to turnaround, maintenance and capital projects, meeting every requirement from planning, scheduling, cost tracking and complete staff execution. Strong relationships are built and maintained. This encourages best practice sharing, resulting in constant examination of how work can be done better, safer, and in a more cost-effective manner.

Team's extensive service offerings combined with its global presence enables prompt response with a comprehensive solution in any situation. The span of its worldwide reach facilitates an unprecedented knowledge of all local safety, quality and compliance requirements.

Additionally, each service is backed by the company's world-class engineering and manufacturing teams. Clients receive components that are designed specifically for the intended job, installed by trained Team technicians.

Having one company to deal with instead of many lends itself to effective time and administrative management. Organizations striving to standardize their safety programs will also find more success with fewer, more-involved suppliers. Efficiency is recognized when the best aspects of both the operator's and the contractor's programs are combined.

Ultimately, each company must know one another's business and establish trust and camaraderie among key players to view the relationship as a win-win strategy. Team recognizes that its global success is ultimately measured by its customers' trust and confidence, which can only be earned through continual outstanding service 24/7/365.

**www.teaminc.com**

# Benefits of Rupture Discs in Pressure Relief Systems

*Learn how rupture discs help prolong the life of pressure relief valves within a chemical manufacturing process.*

Overpressure can have serious consequences, not just damaging equipment and systems, but also potentially leading to personal injury or loss of life. Overpressure in manufacturing processes may be the result of a variety of causes, from runaway reactions and failed regulators, to operator mistakes and faulty equipment.

Pressure relief valves (PRVs) are widely seen as the primary safety solution to combat overpressure. However, protecting these valves is often overlooked.

PRVs are used in almost every industry, so there is a wide variety of process media that they are exposed to. Even where the media seems relatively benign, corrosion and wear and tear are always risks. The risks are higher with more corrosive or viscous media.

The three main issues which can affect PRV's are: product build-up, corrosion and leakage. The following details how rupture discs can help protect and extend the life of PRVs.

## Protect Against Build-Up

Using a rupture disc, the PRV is sealed and is protected from contact with the media. The discs are designed to have no gaps or crevices where product could adhere or build-up, unlike the edges and angles found in a valve inlet design. If there is overpressure, the discs burst – without fragmenting – and allow the relief valve to work as intended. Once the pressure is relieved, the valve will re-seal and the discs can be replaced at a convenient time.

## Protection Against Corrosion

Not only does a rupture disc prevent the media from corroding the valve internals, it also means that it's cost effective to achieve chemical compatibility when special materials of construction are required. By using an upstream rupture disc made from a resistant alloy, the PRV can be made from lower-cost material without any loss of reliability from the pressure safety system.

## Protection Against Leakage

Rupture discs will prevent leakage entirely. This means the PRVs require greatly reduced maintenance. Furthermore, when regular valve set pressure testing is required, this can be done in-situ. The space between the valve inlet and the rupture disc can be pressurized until the relief valve opens, avoiding removal for bench testing and the resulting process downtime. The rupture disc offers a back-pressure allowance, so it will not be affected by such testing.

The use of rupture discs at the inlet of pressure relief valves will improve the level of pressure safety as selected and reduced the need for cleaning, maintenance and repair. Corrosion issues – both upstream and downstream of the pressure relief valve – as well as outage costs can be substantially reduced, leading to better yield of the production site. Ultimately, by adding rupture discs to the inlet of your pressure relief valve, it will result in higher process safety in a facility with reduced costs of ownership. Visit Fike.com for more information about protecting your PRVs with rupture discs.

**www.fike.com**

# Differential Pressure Flow Meters:

## *Versatile Solution for the Chemical Processing Industry*

Flow measurement is a crucial aspect of practically all phases of the chemical processing industry (CPI). The effectiveness of operations depends upon accurate data on fluid flow, as does maintaining compliance with regulations. In addition, a greater emphasis on sustainability is driving manufacturers to closely monitor the consumption of precious resources and the byproducts generated in the process.

Differential pressure (DP) flow meters are versatile instruments employing a well-understood measuring technology that does not require moving parts in the flow stream. In addition, viscosity changes don't affect the devices greatly.

DP flow meters provide a proven solution for a variety of chemical-related applications. For example, Badger Meter has developed innovative DP meters with a cone-shaped element, which shapes the flow profile ahead of the measurement port without impacting the flow against a sharp surface. This creates a stable signal for measurement with minimal wear on the cone edge. Users benefit from low maintenance and long service life.

**Badger Meter** offers a variety of DP flow meters for the CPI, including the Preso® Ellipse® annular flow device. This primary flow meter produces a differential pressure that is proportional to flow. It delivers a true static pressure measurement rather than a calculated value, producing accuracies of ±0.75 percent of reading, repeatability of ±0.1 percent of reading, and a 17:1 turndown ratio with no vacuum effect.

The Preso COIN® flow meter accommodates most flows, even the most abrasive fluids. The basic flow equation for the meter is derived from Bernoulli's Theorem. An engineered restriction creates a differential pressure that equates to a mass or volumetric rate of flow. Different height over diameter ratios are specified to handle different flow ranges. The COIN meter has a unique ability to maintain the necessary square root relationship between flow rate and differential pressure for almost any type of flow.

Preso Venturi flow meters provide highly accurate and repeatable measurements of liquids, gases, and steam. The Venturi restricts the flow at its throat and measures the pressure difference of the unrestricted and restricted flow. This design enables longer lasting accuracy and lower permanent pressure loss than orifice-type meters, reducing maintenance and operating costs.

**www.badgermeter.com**

# Busch Presents New Series of Dolphin Liquid Ring Vacuum Pumps

**Busch Vacuum Pumps and Systems** has now launched an entirely new series of liquid ring vacuum pumps. The new Dolphin LM/LT vacuum pumps have been completely redesigned but are based on proven liquid ring vacuum technology. With these new vacuum pumps, Busch has been able to optimize an existing product that has become an established part of many industrial processes, resulting in the development of extremely powerful, yet energy-efficient vacuum pumps.

Dolphin LM models are single-stage vacuum pumps for the rough vacuum range from atmospheric pressure to 100 Torr ultimate pressure. Dolphin LT models are available in two-stage versions and cover the vacuum range from atmospheric pressure to 25 Torr. A total of 13 sizes are available so that a precisely coordinated solution can be found for any process. Dolphin LM/LT vacuum pumps have a modular design and integrated flow channels. This makes them extremely compact and the optional motor pedestal eliminates the need for base frames, since the NEMA Premium efficiency motor is directly flange-mounted. The new seal concept with mechanical shaft seals, made of FKM or FFKM depending on the pumping medium, ensures a long life cycle. The standard material for the impeller is stainless steel. A stainless steel version of the housing is available as an option.

**Busch has launched two new series of liquid ring vacuum pumps in a total of 13 sizes**

Water or a fluid suitable for the process medium is used as the operating fluid. Ethylene glycol, mineral oils or organic solutions can also be used, as well as condensable in the process gas. Dolphin LM/LT liquid ring vacuum pumps can be operated in once-through circulation systems, in open, or in closed liquid cycles. Their high vapor and particle tolerance makes them exceptionally well-suited for removal/extraction of wet gases or vapors. They are ideal for processing chemicals, pharmaceuticals, foodstuffs, oil and plastics, as well as wood impregnation and drying processes, and many other industrial processes. Dolphin LM/LT vacuum pumps are available in sizes with pumping speeds of 58 to 510 ACFM. Versions for operation in potentially explosive environments are available in different ATEX-compliant versions and temperature classes.

**www.buschusa.com**

# Trusted Maintenance & Turnaround Partner for Over 50 Years

## *Curtiss-Wright EST Group focuses on 'safety' and 'reliability' in Petrochemical and Refining Plants*

Since 1968, **Curtiss-Wright EST Group** has specialized in the design, and manufacture of tools and systems to simplify maintenance of shell & tube and air-cooled heat exchangers, as well as test plug systems to expedite in-service inspection of pipe, pipelines, piping systems and pressure vessels. These plugging and testing systems have saved their petrochemical and refining customers millions of dollars in equipment maintenance and downtime.

Their flagship product, Pop-A-Plug Tube Plugs, offer a permanent cost-effective tube plugging solution for prolonging lifecycles and improving efficiency of air-cooled heat exchangers, condensers, and boilers. A unique breakaway ensures a tightly controlled installation force eliminating damage to tube joints and tube sheets. Pop-A-Plug Tube Plugs eliminate welding and maintain a leak tight seal under extreme thermal and pressure cycling at working pressures to 7,000 PsiG (480 BarG), and are available in over 35 alloys, suitable for aggressively corrosive environments.

In addition, to assist their petrochemical and refining customers isolate/test piping during flange replacement and other pipe repairs requiring welding, EST Group designs and manufactures pressure testing & isolation plugs to expedite testing and/or isolation of piping, tubing, and pressure vessels.

This product line includes their GripTight MAX Test Plugs for high pressure hydrostatic testing at working pressures up to 15,000 PsiG (1034 BarG); GripTight Isolation Plugs for isolating pipe end hot work from potentially explosive upstream vapors; and High Lift Flange Weld Test Plugs for isolating and hydrostatically testing weld joints of any welded flange-to-pipe connection. These plugs eliminate the need to fill entire systems, significantly reducing time and test media needed to perform testing.

Curtiss-Wright EST Group serves a global customer base within refining, petrochemical, fine chemical, pharmaceutical, power generation, oil and gas, and shipbuilding industries. With a large inventory ready to ship and 24/7 emergency manufacturing available, EST Group is here when you need them most!

**www.cw-estgroup.com**

**Pop-A-Plug Tube Plug and GripTight Test & Isolation Plug Product Lines.**

# A choice of solutions for pressure regulation

## *Cashco has launched three new devices for the control of gas pressure*

The new ULR-1 ("Un-Loading Regulator") valve from **Cashco** is more than an enhanced product. It also brings clarification and new information, says Clint Rogers, General Manager of Cashco's Valve Division.

The ULR-1 was originally marketed as the U1 by Kaye MacDonald, which Cashco bought in 1999. Unfortunately, the only documentation for the U1 and similar products was the original schematics, which showed how the tubing and fittings were to be installed, Rogers says.

"Previously, a customer would have had to locate the technical bulletin, work their way through its product coder and then a separate product coder for the correct bill of materials for the hookup," Rogers explains. "Not any more. With these new products, all of the information is in the technical bulletin and the operating manual."

As Rogers explains, the ULR-1 is a DA4 regulator with a Cashco CA1 back-pressure valve mounted onto it. Using the inlet pressure from the valve, the CA1 is set to control the outlet pressure of the main valve. Because the outlet of the CA1 constantly exhausts into the atmosphere, the media through the valve must be environmentally safe gas such as oxygen or nitrogen.

For even more choice in pressure regulation, Cashco has also introduced the SLR-1 and SLR-2 Self-Loading Regulators. The SLR-1 is a high-performance, pressure-loaded, pressure-reducing regulator with a self-contained regulator mounted onto it. Inlet pressure from the main valve is diverted to the pilot, which, in turn, reduces the loading pressure to the cover dome in order to maintain the set point of the main valve. The pressure inside the dome is static, so gas is only released to atmosphere when the outlet pressure setting is reduced or the system is shut down.

**Cashco SLR-1 (left) and SLR-2 (right)**

The new SLR-2 self-loading regulator is similar to the SLR-1, but its loading valve is not self-relieving. Instead, the cover dome bleeds through a filter and check valve back into the outlet of the main valve. This feature allows the SLR-2 to be marketed for hydrogen gas, natural gas and sour gas (NACE) applications.

**www.cashco.com**

# The Petrochemical Industries Best Source for Customized Pollution Control Equipment

*CR Clean Air specializes in wet scrubbing systems offering a wide range of designs and chemical regents to suit equally diverse applications.*

As a leader in pollution control for over sixty years, CR Clean Air has the breadth and depth of experience to meet your plant's needs, no matter what the pollutant. From HCL to NOx, $SO_2$ to Ethylene Oxide we have been there for the petrochemical industry from day one.

For example, our proven approach to Ethylene Oxide removal has been used successfully for over 40 years. By using an acid catalyst to facilitate conversion of Ethylene Oxide to Ethylene Glycol; we can achieve high removal rates (less 1 ppmv at the discharge) with minimal downtime. Our modular approach allows us to skid mount many key components (pumps, exchangers and tanks) as well as pre-fit piping / ductwork at the shop to minimize the time required for field installation.

**CR Clean Air** has the experience to engineer a system that will work the first time, and our commitment to quality ensure that it will continue to work for decades to come. From tank farms to railcar loading / unloading operations; process venting to emergency standby systems, you can trust our technology. Be it a small manually controlled units or a large fully automated systems with complex instrumentation and built in redundancy, our team of electrical, chemical and mechanical engineers are able to assist in developing customized solutions for your plants specific needs.

Our offerings are available in a wide range of materials, both metal and non-metal, including carbon steel, stainless steel, corrosion resistant alloys, FRP, Polypropylene, PVDF and dual laminates. The range of pollutants is also as varied, including HF, $H_2S$, HBR, $NH_3$, Silicates, dust and certain VOC's. CR Clean Air has a range of approaches in its arsenal, be it water once through to chemically scrubbed system complete with recirculation.

From Arsenic to Zirconium Tetrachloride … CR Clean Air scrubs gasses others won't touch. For more information on how a CR Clean Air scrubber fits into your plants environmental compliance please contact us at info@crcleanair.com or visit

**www.CRCleanAir.com**

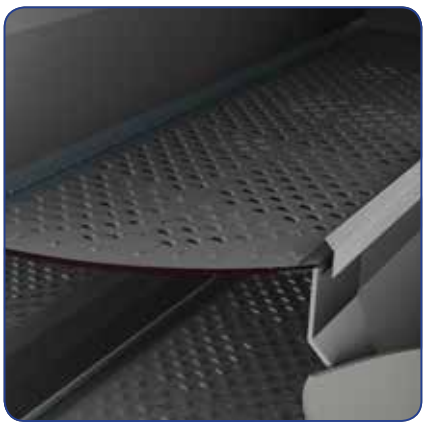
# Optimizing crude oil distillation equipment

With rising global demand, volatile prices and increasingly stringent environmental regulations, oil and gas companies are challenged to reduce their costs while improving their process performance. For over 50 years Sulzer Chemtech has been offering proven, cutting-edge mass transfer components to solve the challenges within the oil refinery and help to boost its performance.

In the downstream sector, **Sulzer Chemtech** designs, manufactures and provides high-performing, state-of-the-art separation systems that maximize the crude oil processing capacity in preflash columns and reduce maintenance costs. Refineries can benefit from Sulzer's proactive approach towards the challenges affecting the processing operations and undermining plant productivity: foam formation, fouling caused by salt deposition or sand/catalyst particles, corrosion and coke formation.

Sulzer Chemtech, a leader in mixing and separation technology, helps the oil and gas industry address these issues by delivering innovative yet reliable solutions and providing a global service and manufacturing network, supported by world class experts.

To avoid the production of foam, a common issue in preflash columns, refineries can adopt Sulzer's innovative solution to mechanically control and break the foam as it forms without the use of chemicals, which impact cost, maintenance and product purity. Sulzer's device, known as Inlet Cyclone or GIRZ, is positioned on the column inlet and utilizes the centrifugal force and the momentum of the feed stream to separate its phases: the gas is released from the top, while the liquid drains into the bottom of the cyclones.



**The chordal downcomer high performance fractionation tray by Sulzer, featuring devices that enhance fouling resistance and hydraulic capacity.**

While the Inlet Cyclone can also partially help preventing fouling and corrosion of the column, refineries can also benefit from Sulzer's specialized column trays and valves designed to minimize fouling, corrosion and coke settling. The VG AF™ trays, equipped with the high lift raised orifice valves XVG™ or SVG™, have excellent fouling resistance, increasing the system reliability, without impacting the column performance.

With Sulzer's solutions for downstream processes, refineries can improve the efficiency and productivity of the processing operations, produce higher quality oil and optimize the service life of its equipment.

Choosing Sulzer and its separation technologies for downstream not only means having access to high-quality, reliable and innovative product, but also to a wide range of dedicated engineering services.

**www.sulzer.com**

# Which Heat Exchangers Are Best Suited For Amine Systems and Sour Water Strippers?

*Kelvion's K°Bloc has been leading the O&G Industry with continuous innovation and proven performance.*

**Kelvion's K° Bloc fully welded heat exchangers are expertly suited for a broad range of liquids, temperatures and pressures.**

Plate & Frame heat exchangers (PHE) have been the preferred technology in lean/rich amine service for decades because they are compact, have high thermal efficiency, and offer a close temperature approach. Nevertheless, some sites have experienced gasket leakage or underperformance. Do these bad experiences disqualify this technology? What would be an alternative technology?

**Kelvion's Gulf Coast After Sales & Service Division is available for onsite and offsite support**

Recently, more end-users are selecting Welded/Bloc Heat Exchangers (WPHE) for the lean/rich amine processing with excellent results. This technology combines the high efficiency of corrugated plates with the robustness of a welded concept. Dangerous leakages of $H_2S$ containing solvents can now be avoided. Now experience is building up and guidelines for design and engineering are being developed. What is a realistic heat transfer coefficient to calculate with in the initial plant design and in what sizes and models is this technology available?

WPHE is a proprietary technology and end-users must rely on the designs of vendors. Nevertheless, guidelines can be given to review the vendor's designs as well as requirements in engineering specifications for pressure drops, flow distribution, and shear stress. International standards such as API 662 for PHE do not yet exist for WPHE. However, these are being developed.

During plant design, choices are made in sparing philosophy and the operational reality is often quite different. Plants with PHEs often have a spare unit. However, instead of using the spare for timely cleaning, they often are put in service to maintain plant performance. This only helps for a short while: lining up the spare unit decreases shear stress and increases fouling rate.

Now there is a growing installed base of WPHEs in amine systems and sour water strippers, and best practices have been developed for cleaning and maintenance. WPHEs also have outstanding performance as Stripper Condensers and Regenerator Reboilers compared to bulky Shell & Tube Heat Exchangers, with significantly lower solvent degradation. Considering the above, it is no surprise that reference lists for WPBHE in Amine Systems and Sour Water strippers is growing rapidly. **www.kelvion.com**

# SUPERFRAC® XT trays for challenging revamps and new builds

The SUPERFRAC® tray family has been proven through more than 25 years of application in the most demanding fractionation, absorption and stripping applications. Through continuing investment in research and development, **Koch-Glitsch** constantly strives to improve the performance of its products and technologies.

Traditionally SUPERFRAC trays were used to revamp existing towers for improved performance, but more commonly they are being specified for new grass roots installations to minimize equipment diameter, height and overall investment cost.

Our latest generation SUPERFRAC® XT tray has demonstrated unparalleled capacity and efficiency in some very notable recent commercial applications.

A 28 ft diameter Propane/Propylene Splitter was recently revamped to improve the tray efficiency at a 25% higher feed rate. From initial start-up, the original 4-pass fixed valve trays had been plagued by low tray efficiencies, resulting in a significant shortfall in polymer grade propylene production. 6-pass SUPERFRAC XT trays were selected for this revamp, which included extensive use of OMNI-FIT technology to avoid welding directly to the tower shell.

A very aggressive installation schedule required a ONE SOURCE SOLUTION approach, where the Koch-Glitsch equipment design team and the Koch Specialty Plant Services installation team worked seamlessly together to minimize the revamp duration. Removal of the existing trays and installation of the new trays took only 38 working days.

Following the revamp, the overall tray efficiency increased from approximately 78% to 94%. The tower is now meeting the product purity goal at the higher feed rate.

An even larger Propane/Propylene Splitter has been in service for over 2 years with 8-pass SUPERFRAC XT trays. The 33.5 ft diameter vessel was designed with SUPERFRAC XT trays and has exceeded design capacity and product purity requirements right from the initial start-up. The overall tray efficiency is above 90%, which exceeds the design basis, allowing the reflux ratio to be optimized to minimize energy consumption.

High tray efficiencies and capacities can be obtained with optimized SUPERFRAC XT trays. In C2 and C3 splitters efficiencies of 92 – 100 % have been demonstrated. This allows debottlenecking of existing splitters or a reduction in diameter and height for grassroots splitters. It also allows the energy consumption of these mega towers to be minimized. In the case of heat-pump splitters, it also minimizes the energy consumption and size of the heat-pump system.

It is no longer necessary to find a trade-off between capacity and efficiency. Contact your nearest Koch-Glitsch office to evaluate the possibilities the SUPERFRAC tray family can offer!

**www.koch-glitsch.com**

# Innovative Automation Delivers More Successful Project Execution and Operations

*Emerson's newest control system enhancements enable petrochemical and refining organizations to improve long-term operations*

Petrochemical and refining organizations have made great improvements to project execution and operations in recent years to capture strong market opportunities. Despite adopting new technologies and reducing costs, millions or billions of dollars in opportunity for improvement remain untapped. **Emerson**'s Project Certainty and Operational Certainty initiatives have been key foundational elements aimed at recouping that lost revenue.

To help organizations take advantage of untapped opportunities, Emerson is enhancing every layer of its DeltaV distributed control system—I/O, controller, communications and enterprise layers, and HMI—to deliver more efficiency and more secure lifecycle value, all within an advanced certified cybersecure framework.

## Smart Commissioning

Drastically reducing commissioning time and effort, Smart Commissioning streamlines the commissioning of field instrumentation. Automatic binding, device configuration, testing, and documentation eliminate manual work and reduce trips and also take commissioning off a capital project's critical path.

## DeltaV PK Controller

Powerful standalone. Easily integrated. The DeltaV PK Controller is designed with flexibility in mind for project execution support and operational efficiency. Built to a smaller footprint, the DeltaV PK Controller delivers the features of a full-scale DCS. Designed to help organizations efficiently achieve the benefits of skids and modular construction, the DeltaV PK Controller can run headless, with a local operator interface, or be easily integrated into a plant-wide DeltaV system.

## DeltaV Live Operator Interface

A modern, built-for-purpose operations experience that makes graphic design easy. DeltaV Live provides a world-class operations experience, designed for today's high-performance operator requirements. This highly-customizable Human Machine Interface (HMI) is Emerson's first to natively support HTML5, laying the foundation for universal, cross-platform graphics that are easy to design, configure, and maintain.

## DeltaV Mobile

DeltaV Mobile allows engineers, managers, and operators to unleash their operations performance potential with easy, secure, on-demand access to manufacturing data—anywhere and anytime.

**www.Emerson.com/DeltaV14**

# Breakthrough in Flare Gas Measurement

*Sierra's QuadraTherm® Thermal Dispersion Mass Flow Meters Offer Real-Time Adjustment for Changes in Gas Composition at Low Flows*

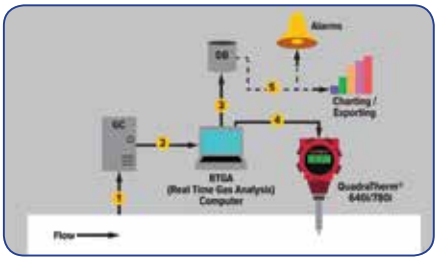
One of the major challenges oil & gas engineers face for EPA compliance is accurately measuring gas mixtures with changing gas compositions in applications like distribution systems, flare gas produced in refineries and other petrochemical applications. Accurately measuring the flow of gas mixtures is often complicated by gas density changes over time. Over the last five years, multi-path ultrasonic meters have been an ideal technology for applications with changing gas compositions. Ultrasonic meters infer density from the speed of sound; therefore, they are immune to changes in gas composition. However, recent updates to federal like EPA 40 CFR Part 60 Subpart OOOO (also known as Quad O) require accuracy with changing gas compositions at flow rates as low as 0.1 fps (0.03 mps). Ultrasonic flow meters can only measure flow greater than ~1 fps. Even though ultrasonic meters can handle changes in gas composition, they cannot measure down to the required low flows for EPA compliance.

## Thermal Flow Meters Ideal for Low Flows

Now for the first time in history, chemical engineers have a viable alternative to ultrasonic technology to comply with these EPA regulations. **Sierra**'s QuadraTherm® thermal mass flow meter with qMix-RealTime™ software has a wide flow range of 0.1 to 1000 sfps (0.03 to 305smps) and the ability to compute the properties of a specified gas mixture to manage changes in gas composition, gas temperature, gas pressure, and outside temperature.

## qMix-RealTime App Adjust for Changing Gas Compositions

To take this technology a step further, QuadraTherm thermal flow meters with qMix-RealTime™ provide real-time adjustments to gas composition changes by integrating with a compositional sampling device, such as a gas chromatograph. The gas chromatograph determines the properties of the gas mixture as they occur real-time. This data is relayed to the meter and direct adjustments to the gas composition are then applied to the meter calibration settings. QuadraTherm® with qMix-RealTime™ adjusts mixtures and percentages within seconds to match real-time readings from your GC—all while retaining accuracy with no recalibration needed.




**Sierra's QuadraTherm® Thermal Mass Flow Meter with qMix-RealTime™ app**

Discover how you can comply to EPA regulations & improve your process, download a copy of Sierra's FREE Flare Gas Tech Application note.

**www.sierrainstruments.com/flaretechnote**

# Water analysis made easy

*Myron L Co. supplies a wide range of portable instruments for water professionals*

The **Myron L® Company**'s new ULTRAPEN™ PTBTx™, wireless Pocket Testers are designed to be paired with any Apple® iOS 8+ device via the ULTRAPEN's Bluetooth® BLE transceiver. A free App takes advantage of Apple's iOS GUI to provide easy-to-read displays and a simple-to-use interface. The Bluetooth link means that there are no bothersome wires getting in the way when moving quickly between samples and that paired mobile devices can be held safely away from liquids.

Advanced features include: Automatic temperature compensation; stable microprocessor-based circuitry; user-intuitive design and a rugged, waterproof housing.

Available models:

- PTBT1 - Conductivity, Total Dissolved Solids (TDS), Salinity, and Temperature measurement with three, selectable solution modes that model commonly encountered water types.
- PTBT2 – pH and Temperature measurement with 1, 2, and 3 point calibration options.
- PTBT3 - ORP & Temperature measurement.

Using your ULTRAPEN iOS App:

- Each ULTRAPEN PTBTx can be given a unique name stored in the ULTRAPEN's memory so it is easily identifiable no matter what mobile device is used.
- Measurement locations can be programmed as:
  - GPS locations that are automatically selected when the user is close to a specific measurement local, or;
  - Non-GPS locations ideal for applications where the sample sites are too close together for the GPS to discriminate.
- Measurements can be saved to the mobile device's memory including measurement data, ULTRAPEN settings, sample temperature, ULTRAPEN name and measurement location.
- Records can be exported via the mobile device's email function as either .csv, .xls, .xlsx formatted files or using Myron L Company's .mlc, proprietary, encrypted format.
- Stored measurements can be sorted or filtered and then emailed or deleted without affecting other records stored in memory.

Coming Soon:

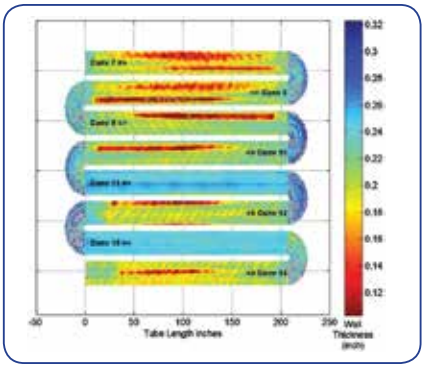
- PTBT4 - Free Chlorine Equivalent (FCE™) & Temperature measurement.
- Android™ compatible App.

**www.myronl.com**


**The ULTRAPEN PT5 measures dissolved oxygen accurately, in a package that is both rugged and ultra-portable**

# Optimizing critical fired heaters is now easier than ever

*Quest Integrity provides industry expertise and engineering optimization planning and management to increase the life cycle value of fired heater assets*



**Ultrasonic inspection data indicating areas of severe wall thinning in fired heater tubing**

Unexpected asset failures present a number of complications to a facility, including costly repair and production interruptions. Historically, asset reliability and management methodologies have been reactive – only adjusting practices once a costly failure has already occurred. However, today's modern technologies allow operators to proactively manage their assets, mitigating many of the risks associated with premature asset failure. Significant improvements in technology innovation and reliability practices provide operators with life extension opportunities that were not available just a decade ago.

**Quest Integrity** understands that unique assets require unique solutions. Due to specific operator and individual asset requirements, a general model for asset integrity optimization is not an effective long-term solution. A powerful optimization management strategy should be specifically designed to address the current and future condition of the asset, achieving a higher level of performance and reliability, while decreasing the risk of unplanned shutdowns. Customized for the life-cycle of each individual fired heater asset, Quest Integrity's Fired Heater Optimization program consists of a multi-disciplinary inspection and engineering approach that includes tube creep and corrosion damage measurement and assessment, infrared thermometry (IR) data management, ultrasonic in-line inspection and remote digital visual inspection (RDVI). A variety of engineering assessments, including fitness-for-service, remaining life, risk assessment and failure analysis are utilized to significantly extend asset life, effectively managing cost and preventing catastrophic failures.

Depending on the condition of an asset, Quest Integrity's team of dedicated technical experts assist operators in determining the appropriate strategic action plan to ensure optimal performance and reliability of fired heaters.

Quest Integrity is a global leader in the development and delivery of asset integrity and reliability management services and solutions. The company's solutions consist of technology-enabled, advanced inspection and engineering assessment services and products that help organizations improve operational planning, increase profitability, and reduce operational and safety risks.

**www.questintegrity.com**

# Lighten up! Automated pressure calibration has arrived

Process control technicians in chemical processing are responsible for maintaining strict calibration standards of multiple types of instrumentation that control pressure for processes. To maintain the highest level of accuracy and integrity, pressure instruments are frequently calibrated to ensure they are operating according to specifications. Indeed, a typical pressure calibration can require testing anywhere from three to eleven pressure test points—each requiring time-consuming readjustments and fine-tuning using the fine adjust vernier of the test pump. Small pressure leaks in the test setup only complicate the calibration process.

## Automatic pump a game-changer

One process control technician recently noted that for many years he calibrated pressure instruments using a documenting process calibrator. However, when he saw a demonstration of a new portable automatic pressure calibrator with a built-in automatic pump he immediately saw the benefits.

"It's like a one-stop shop to accomplish our calibrations, versus having to carry multiple components like a hand pump and a vacuum pump," the technician says.

## Test like a savvy veteran

The new 729 Automatic Pressure Calibrator combines the pump, vernier and to some degree incorporates many of the skills of a pressure specialist in one portable tool. This new calibration tool helps technicians new to pressure calibration perform calibrations like a savvy veteran. Type in the pressures and number of steps needed and the 729 automatically steps from one pressure test point to the next, documenting the applied pressures and the corresponding response from the pressure transmitter.

## Saves technician wear and tear

A control technician notes that, not only does the automatic pump save time, it is more ergonomic because he no longer has

to pump up the pressure by hand. This reduces wear and tear on technicians over several calibrations.

"When we check our pressure transducers we have to pump it up as high as 300 psi. I just enter the pressure required and (the calibrator) automatically pumps up to that level." The technician emphasized that the more advanced automatic calibrator reduces hand pump instrument error and reduces calibration time by about 40 percent.

## Time savings adds up

Additional capabilities such as the ability to measure, source, and simulate 4 to 20 mA signals also increases efficiency. Each incremental unit of time savings adds up with hundreds of control devices that need calibrating to support dozens of research projects running at a time in the facility.

**www.fluke.com**

# Zeeco Introduces Accurate, Real Time Flare and Pilot Monitoring Technologies

The **Zeeco** VerifEye fiber optic pilot monitoring system delivers a new level of instantaneous, discrete, and automatic flare pilot detection. It uses fiber optics integrally mounted in the flare pilot to relay the status of each unique pilot flame to an at-grade monitor in real-time. An optical sensor in the monitor discerns pilot status from background flame and controls pilot ignition and function.

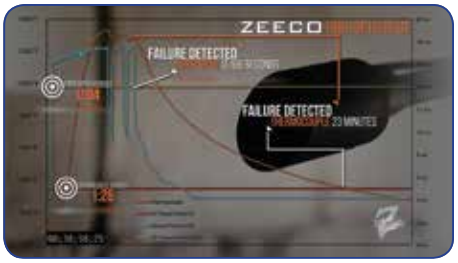
To eliminate maintenance issues, the system is constructed for high-temperature applications and focuses on the pilot flame from a safe distance within the pilot well — not in contact with any combustion. The fiber optic assembly is centered in the air-gas premix piping. The continuous flow of air and gas during operation provides creates a thermal barrier against combustion temperatures.

To help facilities meet the January 31, 2019 deadline for compliance with the EPA final rule known as 40 CFR Part 63 Section CC, Zeeco developed a patented new direct flare monitoring system using Video Imaging Spectro-Radiometry (VISR) named FlareGuardian. FlareGuardian eliminates the inaccuracies and delayed results inherent to indirect flare monitoring. Unlike a passive Fourier Transform Infrared (FTIR) system, FlareGuardian's VISR technology, a real-time advanced multi-spectral Infrared (IR) imager that directly and remotely monitors flare performance, captures all the spectral bands for each pixel at the same time. The accuracy of the VISR technology removes the need for indirect surrogate parameters such as Combustion Zone Net Heating Value (CZNHZ) and tip velocity. The FlareGuardian system can automatically adjust supplemental fuel additions, as well as any assist source (gas, steam, or air) via a closed-loop control system – lowering costs for supplemental fuel while maintaining required destruction efficiency (DE).

FlareGuardian allows operators to eliminate tedious aiming, data reduction, and ongoing operation and maintenance costs associated with other flare monitoring methods while staying in compliance with the EPA Refinery Sector Rule (RSR) 40 CFR 63.670. Previously, flare operators have been limited to indirect flare monitoring options including Gas Chromatograph (GC), calorimeters, flare gas flow meters and monitoring, and steam / air controls. Now, the maintenance and calibration-free Zeeco FlareGuardian offers an alternative direct monitoring system that eliminates ongoing maintenance and operational costs.

For more information: sales@ zeeco.com or call 918-258-8551

**www.zeeco.com**




**Zeeco's VerifEye fiber optic system instantaneously registers pilot ignitions and failures.**

# Economic Indicators

2016 2017 2018

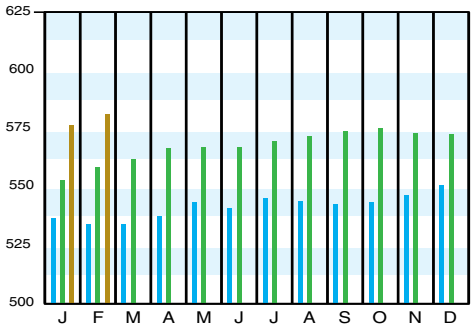
**Download the CEPCI two weeks sooner at www.chemengonline.com/pci**

## CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

| (1957–59 = 100) | Feb. '18 Prelim. | Jan. '18 Final | Feb. '17 Final |
|---|---|---|---|
| *CE* Index | 581.2 | 576.4 | 558.3 |
| Equipment | 703.3 | 697.4 | 672.0 |
| Heat exchangers & tanks | 616.3 | 606.1 | 587.3 |
| Process machinery | 700.4 | 697.0 | 671.1 |
| Pipe, valves & fittings | 903.6 | 910.2 | 852.0 |
| Process instruments | 417.0 | 415.9 | 403.0 |
| Pumps & compressors | 1009.6 | 1001.0 | 973.1 |
| Electrical equipment | 532.0 | 531.2 | 512.1 |
| Structural supports & misc. | 755.5 | 736.1 | 729.7 |
| Construction labor | 330.9 | 328.7 | 323.1 |
| Buildings | 576.6 | 570.5 | 552.2 |
| Engineering & supervision | 311.7 | 308.7 | 315.0 |

Starting with the April 2007 Final numbers, several of the data series for labor and compressors have been converted to accommodate series IDs that were discontinued by the U.S. Bureau of Labor Statistics

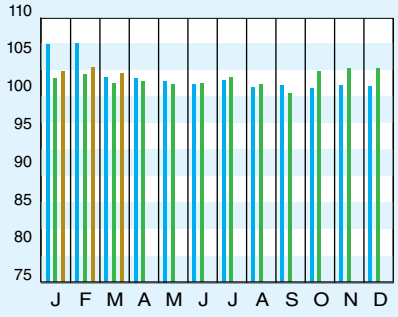
Annual Index:
2010 = 550.8
2011 = 585.7
2012 = 584.6
2013 = 567.3
2014 = 576.1
2015 = 556.8
2016 = 541.7
2017 = 567.5



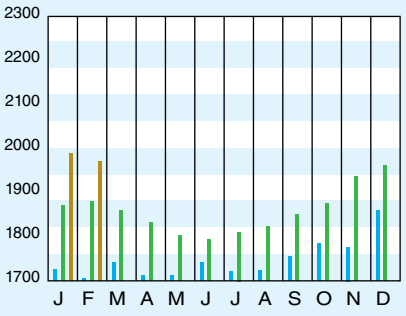

## CURRENT BUSINESS INDICATORS

| | LATEST | PREVIOUS | | YEAR AGO |
|---|---|---|---|---|
| CPI output index (2012 = 100) | Mar. '18 = 102.6 | Feb. '18 = 102.4 | Jan. '18 = 100.9 | Mar. '17 = 99.5 |
| CPI value of output, $ billions | Feb. '18 = 1,970.4 | Jan. '18 = 1,991.2 | Dec. '17 = 1,970.4 | Feb. '17 = 1,842.8 |
| CPI operating rate, % | Mar. '18 = 76.5 | Feb. '18 = 76.4 | Jan. '18 = 75.4 | Mar. '17 = 75.1 |
| Producer prices, industrial chemicals (1982 = 100) | Mar. '18 = 269.1 | Feb. '18 = 274.5 | Jan. '18 = 267.2 | Mar. '17 = 253.7 |
| Industrial Production in Manufacturing (2012 =100)* | Mar. '18 = 104.2 | Feb. '18 = 104.1 | Jan. '18 = 102.6 | Mar. '17 = 101.1 |
| Hourly earnings index, chemical & allied products (1992 = 100) | Mar. '18 = 190.2 | Feb. '18 = 188.1 | Jan. '18 = 187.3 | Mar. '17 = 172.3 |
| Productivity index, chemicals & allied products (1992 = 100) | Mar. '18 = 96.6 | Feb. '18 = 96.5 | Jan. '18 = 96.9 | Mar. '17 = 98.3 |

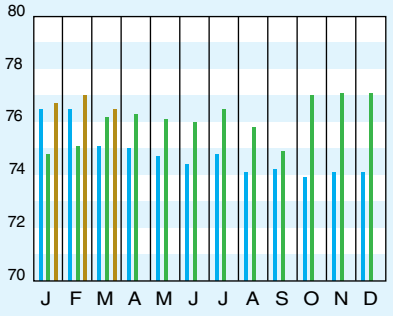
### CPI OUTPUT INDEX (2000 = 100)†




### CPI OUTPUT VALUE ($ BILLIONS)




### CPI OPERATING RATE (%)




*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2000 to 2012
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

## CURRENT TRENDS

The preliminary value for the February 2018 *CE* Plant Cost Index (CEPCI; top; most recent available) increased compared to the previous month's value. All four of the subindices (Equipment, Buildings, Construction Labor and Engineering & Supervision) moved higher for February, pushing the overall monthly CEPCI value for February up. The Buildings subindex had the largest percentage increase of the four. The overal CEPCI for February stands at 4.1% higher than the corresponding value from February of last year. Meanwhile, the Current Business Indicators (CBI; middle) showed a small increase in the CPI output index for March, and a similar increase in the Productivity index for chemical and allied products.